A Strategy for Overcoming Barriers to the Successful Implementation of Lean Construction in the UK

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A Strategy for Overcoming Barriers to the Successful Implementation of Lean Construction in the UK

A dissertation submitted by

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This dissertation is submitted to the University of Plymouth in partial fulfilment of the course requirements for the degree of

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Copyright Statement

Dedicated to:

Almighty Allah (God) who always blessed me for what I asked and even for what I did not ask. All the thanks and praises to Allah.

My beloved parents, as without their unconditional love and prayers I was unable to achieve the goals of my life. Whatever the time it was, their love and warmth protected me like warmth of the sun in winters and shelter in rain.

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ABSTRACT

Lean construction efforts could prove to be highly rewarding for the construction industry. Although various countries gained large benefits by adopting the lean concepts, there seems to be a scarce implementation of lean in the UK construction industry over the last two decades even after the publication of the Egan report. Building upon the methodologies and conceptual frameworks used in earlier work in the UK (Common *et al.,* 2000), the Netherlands (Johansen *et al*., 2002), and Germany (Johansen & Walter, 2007), this study carried out a similar survey to evaluate lean construction as practiced in the UK, and identify the barriers to its successful implementation.

A theoretical framework was adopted and modified by the author to keep up with the vast developments made among the lean construction community since previous studies were carried out; and it formed the basis for a questionnaire survey. The data obtained was then subject to secondary analysis on top of quantitative and qualitative systematic evaluation. Six different classifications were established and analysed during secondary stage. This allowed trends and contrasting views to be determined, and thus more comprehensive findings to be concluded. After completing the results they were informed further by undertaking interviews with a number of professionals from the UK construction industry.

It was found that the majority of the construction organisations do not yet have a holistic view of the full potentials of lean; and that there is still a significant lack of understanding of how to successfully apply lean principles to construction processes and activities. The study concluded the significant barriers to the successful implementation of lean construction in the UK; and proposed a strategy for overcoming the barriers identified.

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At no time during the registration for the degree of Master of Science in Civil Engineering has the author been registered for any other University award without the prior consent of the Graduate Committee.

The study is the work of the author only.

Signed: _____

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LIST OF ABBREVIATIONS

Abbreviation	Description
BAA	British Airport Authority
BIM	Building Information Modelling
BMO	Behavioural-Performance-Outcome
BoQ	Bills of Quantity
BREEAM	BRE Environmental Assessment Model
BS	British Standard
CE	Concurrent Engineering
CESSM	Civil Engineering Standard Method of Measurement
CFP	Continuous flow processing
CPM	Critical Path Method
CPP	Critical Path Planning
CSCS	Construction Safety Certification Scheme
D&B	Design & Build
Design Quality Indicator	DQI
DSM	Design Structure Matrix
ECI	Early Contractor Involvement
HA	Highways Agency
HALMAT	Highways Agency Lean Maturity Assessment Toolkit
Highway Engineers	HE
ICE	Institution of Civil Engineers
IGLC	International Group for Lean Construction

IPD	Integrated Project delivery
JIT	Just in Time
KPI	Key Performance Indicator
LC	Lean Construction
LCI	Lean Construction Institute
LCI-UK	Lean Construction Institute in the United Kingdom
LoB	Line of Balance
LPDS	Lean Project Delivery System
LPS	Last Planner System
MIT	Massachusetts Institute of Technology
PDCA	Plan-Do-Check-Act
PMS	Performance Measurement System
PPC	Percent Planned Complete
QMPMS	Quantitative models for performance measurement systems
RPS	Reverse Phase Scheduling
SCM	Supply Chain Management
TFV	Transformation-Flow-Value generation
TQM	Total Quality Management
UK	United Kingdom
VDS	Virtual Design Studios
VM	Visual Management
VR tools	Virtual Reality tools

CHAPTER ONE - INTRODUCTION

1.0 Introduction

The Construction industry, according to researchers, is seen as a slow progressing industry with frequent problems, for example low productivity, unsatisfactory quality, time overruns and poor safety records; such problems obstruct client delivered value (for example, see Latham, 1994; Egan, 1998). Over the past 60 years, the UK construction industry has been subjected to various reports with the aim of reviewing its performance and suggesting means of improvement (Simon, 1944; Emmerson, 1962; Banwell, 1964; British Property Federation, 1983; Latham, 1994). The latest of these was the Egan report „Rethinking Construction" which was produced in 1998, due to the increased issues concerning the value that UK construction clients perceived. It was noted that although various tools and techniques were seen to be used, the end result from the client"s perspective was still not satisfactory (Garnett *et al.*, 1998). At the heart of the Egan report was a desire to develop a change in culture, style and process of the industry (Blockley & Godfrey, 2000; Forbes & Ahmed, 2011). Based on that, the Egan committee identified five key drivers of change which they believed are just as applicable to construction as well as to any business concern. These are shown in Figure 1.1.

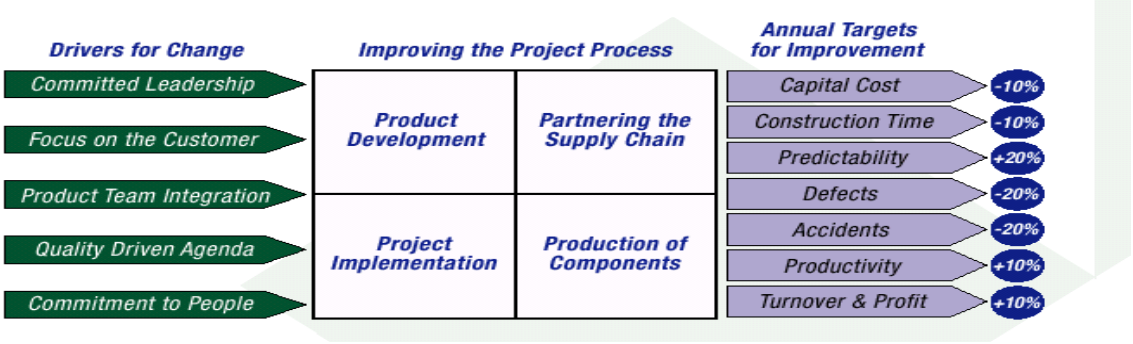

Figure 1.1: The Egan Challenge (Egan, 1998)

In addition, the report pointed out some case studies from around the world where construction was attaining improvement. Amongst these were examples of lean thinking being applied by other leading companies. Egan (1998) says of Lean:

> "*Lean thinking presents a powerful and coherent synthesis of the most effective techniques for eliminating waste and delivering significant sustained improvements in efficiency and quality*." Furthermore, "*we recommend that the UK construction industry should also adopt lean thinking as a means of sustaining performance improvement''*

Although engaging in lean construction efforts could prove to be highly rewarding for the UK construction industry, there has been a scarce implementation of lean over the last two decades even after the publication of the Egan report (Mossman, 2009; Bashir *et al.*, 2010). There seems to be some structural and cultural barriers that prevent its successful implementation.

1.1 Aim

The aim of this research is to evaluate lean construction, as practiced in the UK, to identify barriers that may prevent its successful implementation and to propose a strategy for overcoming the barriers identified.

1.2 Objectives

The main objectives of this thesis are to:

- Review literature relating to lean construction as practiced in the UK;
- Identify barriers to the successful implementation of lean construction in the UK;

- Evaluate the effect of the barriers on the successful implementation of lean construction in the UK;
- Propose a strategy to overcome the barriers identified.

1.3 Structure of the Thesis

The structure of the thesis reflects a conscious choice of organising the work so that it is easy for the reader to follow. Therefore, to aid the comprehension of this thesis a synopsis of each chapter is provided below:

Chapter 2 Literature Review

This chapter reviews literature relating to lean construction as practiced in the UK, barriers to the successful implementation of lean construction, and different performance measurement methods. Also, a modified conceptual framework will be illustrated by the end of the chapter.

Chapter 3 Research Methodology

This chapter describes the research methodology used in the thesis.

Chapter 4 Results and Analysis

In this chapter, the results of the data obtained through the pilot studies, electronic survey and interviews are summarised and analysed. Also, secondary analysis will be conducted.

Chapter 5 Discussion

In this chapter, the results and findings of the collected data are discussed and examined to determine both their validity and their impact upon the aims and objectives for this study.

Chapter 6 Conclusions and Reflections

In this chapter the conclusions and the main findings of the study are summarised. Also, some reflections on the outcomes of the study and recommendations for future research are provided; followed by a list of references and appendices to support the findings of the study.

CHAPTER TWO: LITERATURE REVIEW

2.1 Transforming Construction Using Lean Thinking: Lean Construction

Lean thinking is a philosophy based on the concepts of lean production (Koskela, 1992; Koskela, 2000). According to Smook *et al.* (1996), Common *et al.* (2000), and Mossman (2009) lean principles date back at least as far as the early 1900"s, when Henry Ford introduced the principle of the assembly line that revolutionised car production. In the early 1950"s, lean production management principles were developed by Toyota led by engineer Ohno (Womack *et al.*, 1990). Taiichi Ohno, the father of the Toyota Production System, focused his efforts into finding ways to convert waste „muda" into value, and to alter attentions and thoughts from the narrow focus of craft production on worker productivity and mass production on machine to the entire production system (Womack & Jones, 1996; Howell, 1999). According to Womack *et al.* (1990) the term "*lean*" was invented by the research team working on the International Motor Vehicle Programme (IMVP) at Massachusetts Institute of Technology (MIT) to reflect both the waste reduction nature of the Toyota production system and to contrast it with craft and mass forms of production.

Alternatively, the first consideration of the ideas of lean production for use within construction is attributed to Koskela (1992) (Garnett *et al.*, 1998; Mossman, 2009). This seminal technical-report carefully considered the ideas expressed in the *Machine that changed the World* within a construction context (Garnett *et al.*, 1998). Koskela (1992) formulated the transformation-flow-value generation model of production, known as the TFV theory of production, which could lead to improved performance when applied to construction. He proposed the need to review construction production as a combination of

conversion and flow processes to remove waste, when traditional thinking of construction was only focusing on conversion activities and ignoring flow and value considerations (Garnett *et al.*, 1998; Senaratne & Wijesiri, 2008). Here, 8 types of waste are commonly agreed up on: Transportation, Inventory, Motion, Waiting, Over-Production, Over-Processing, Defects, Skills Misuse (Terry & Smith, 2011).

Since then, researchers started working closely with practitioners investigating the TFV theory and lean techniques (Alves & Tsao, 2007). Also, its publication initiated the formation of the International Group for Lean Construction (IGLC) in 1993, followed by other initiatives such as the Lean Construction Institute (LCI) in 1997; to promote lean principles in construction (Common *et al.*, 2000).

Consequently, Womack and Jones (1996) described the thought process of *lean* and established the five principles of lean production. This theoretical foundation is called „Lean Thinking" by them to differentiate from pure production activities (Terry & Smith, 2011). The five principles of *lean* are (Womack & Jones, 1996):

1. Specify **value** from the customer"s perspective;
2. Identify and integrate the processes that deliver value (**value stream**). This is the sequence of processes from raw materials to product (the supply chain). To achieve this, you need to (i) map the value chain and (ii) eliminate waste;
3. Make value **flow** by eliminating bottlenecks and disruption. Never stop a value adding step by a non value adding step;
4. Let the customer **pull** the product through the manufacturing process. Produce only what is wanted when it is wanted;

5. Pursue **perfection** through continuous improvement. This is not just restricted to quality; it is extended to include producing exactly what the customer wants when it is wanted at a fair price with zero waste

According to Garnett *et al*. (1998), the work done by Womack and Jones (1996) was seen as a strategic approach to achieving the lean production system described in the 1990 publication. „"In a sense it was the general management philosophy alluded to by Koskela"" (Garnett *et al.*, 1998).

Founded in 1997 by Howell and Glenn Ballard, the LCI developed the Lean Project Delivery System (LPDS) and the Last Planner System (LPS) of Production Control, applying principles pioneered in manufacturing to construction (Ballard, 2000). The LPDS is divided into four interconnected phases: project definition, lean design, lean supply, and lean assembly. The Last Planner system is a tool which concentrates on the planning function of construction, using functions such as: „Look-Ahead Plan" to plan what can be done when constraints are removed, and the „Percent Planned Complete" (PPC) which monitors the Look-ahead Plan and requires reasons for delays, which are analysed in terms of root causes (Ansell *et al.*, 2007).

Lean Construction (LC) is a different project management approach because it: has a clear set of objectives for the delivery process, is aimed at maximizing performance for the customer at the project level, designs concurrently product and process, and applies production control throughout the life of the product from design to delivery (Howell, 1999). Abdel-Razek *et al*. (2007) believe that the core idea of LC is to reduce or eliminate waste, represented in non-value adding activities, and increase the efficiency of value adding activities. However,

according to Koskela (1992) and Thomas *et al.* (2002) LC includes: practice of just in time (JIT), use of pull-driven scheduling, reduction of variability in labour productivity, improvement of flow reliability, elimination of waste, simplification of the operation, and implementation of benchmarking.

Evidence of the use of lean thinking has shown that there are benefits to be made from applying lean principles to construction. These benefits claimed include: improved productivity, increased reliability, improved quality, more client satisfaction, increased predictability, shortened schedules, less waste, reduced cost, enhanced build-ability improvements to design, and improved safety (Lehman & Reiser, 2004; Mossman, 2009).

2.2 The Dissemination of Lean within the UK Construction Industry

According to Johansen *et al.* (2002), since 1998 the UK construction industry has seen Government setting up bodies to support it in its drive, inspired by the Egan report, to improve its financial performance, provide a better product and service to its customers, and cope with a skills shortage. Also, there have been efforts towards encouraging the use of lean concepts in construction in most geographical areas of the UK, such as the seminars staged by CIRIA and CPN (Johansen *et al.*, 2002). These efforts were extended to include the Construction Lean Improvement Programme (CLIP) created by BRE in 2003, case studies by Construction Excellence, the establishment of the LCI-UK, and some LC consultancy and promotional companies. More recently some organizations and universities offer LC education, attempting to make *lean* a part of mainstream education.

Despite these continuous efforts, a study by Common *et al.* (2000) has shown that there appears to be significantly less lean culture in UK construction companies than is professed. An even larger gap is evident from the level of development recognized in the LC literature review in other countries, in comparison to those in UK (Common *et al.*, 2000). Also, Green & May (2005) state that there is a noteworthy lack in any empirical research which tests the way *leanness* is diffused or enacted in practice. This is emphasised by Bashir *et al.* (2010) who mentioned that although various countries gained large benefits by adopting LC concepts, it does not seem to be generally applied amongst UK construction organizations. Therefore, the first objective of this study is to evaluate LC as practiced in the UK, and measure the transferability of lean principles to construction.

Moreover, there is still no agreed definition for LC even within the IGLC and LCI communities (Mossman, 2009). This is supported by Green & May (2005) who stated that there continues to be much debate regarding the definition of LC and the meaning of *lean*. *„Any such discussions must start with the ideas of Lean Production"* (Green & May, 2005). Although Mossman (2009) acknowledged that the lack of a common understanding and agreed definition of LC may slow down its take up, he also believed that this may not be a problem; this is as the competing definitions give an indication of the margin between what could be generally accepted as lean and what is not. At least, at the moment it is easy to recognise its absence. Mossman (2009) also suggested that the transformation in thinking is more important than the definition and is therefore a prerequisite for *lean*.

2.3 Lean Construction Practices in the UK

Implementing lean concepts means applying tools and techniques throughout the processes of a project; where a theoretical basis is provided through the TFV theory and further aspects of management theory and complexity theory (Johansen & Walter, 2007).

In UK the British Airport Authority (BAA), has led the way, encouraging its integrated supply chain to adopt lean practices on airport projects (Mossman, 2009). These practices included the use of Last Planner System (LPS) for planning and control, creating a single 3D computer model, and benchmarking to measure performance (Potts, 2008). Potts (2008b) considers the Terminal 5 (T5) project to be the turning point in embracing the principles of LC in the UK; this has required a complete change in the mindset and culture of the participants. However, it is important to stress that a client *pull* approach (intrinsic motivation) is considered more effective for the successful implementation of LC than a client *push* approach (Henrich *et al.*, 2006).

Additionally, in April 2009, the Highways Agency (HA) Lean Improvement Division was created, with a focus on delivering the benefits of lean by applying the principles to HA processes (HA, 2009b). From that time, the HA engaged their supply chain in lean processes with varying levels of success. Some of the lean improvement techniques they use comprise: Six Sigma tools such as the DMAICT process improvement method, lean visual management, collaborative planning using LPS, and the HA lean maturity assessment toolkit (HALMAT) for assessing supply chain adoption of a continuous improvement culture (HA, 2009a).

In 2005, a LC trial was carried out on a highways maintenance project undertaken by a partnering framework, where a lean programme was produced. Introducing the lean process to a highways scheme was a challenge because although LC was applied to building projects, it was seen that a building site is different to the highways construction environment (Ansell *et al.*, 2007). However, the lean programme comprised three main activities: constraints analysis, delay analysis and buffer analysis. Also, a weekly plan attainment chart showing the percentage of activities completed each week against the weekly plan was produced as a bar chart (Ansell et al., 2007). Ansell *et al.* (2007) found that both problems and benefits were encountered in applying *lean* to the project. Many areas were seen as successful during the lean pilot scheme and could be carried on as tools to be used on future projects. These included: the use of a Construction Management Framework (CMF), working in a collaborative environment, Early Contractor Involvement (ECI) during the design stage, the appreciation of the value of the constraints analysis, weekly planning, and to some extent the delay analysis (Ansell *et al.*, 2007). On the other hand, the main problems identified were the lack of commitment and a good understanding by the team members of *lean*, and some misunderstanding of what was trying to be achieved. This addresses the need for developing system thinking and culture change if *lean* is to be continued successfully onto other schemes (Ballard & Howell, 1998; Seymour, 1998; Johansen *et al.*, 2004).

In case of applying LC to construction buildings, Common *et al.* (2000) carried out a survey to test the take-up of lean concepts among UK construction companies. In their work they identified four areas as being fundamental in developing a lean culture: Procurement, Planning, Control and Management. Within each area they identified a number of techniques that were seen as being suitable for the successful implementation of LC; namely, Design & Build (D&B) , Last Planner System, Look-ahead Planning, Supply Chain Management

(SCM) and Partnering. The survey showed that there has been some adoption of lean techniques; nevertheless the problem is that these existed alongside traditional approaches (Common *et al.*, 2000). Also, the companies implemented a mixture of techniques that were thought to be lean but which in fact added waste to the process. Examples of these are: using traditional contracts as a primary route of procurement for most contractors, and critical path planning (Common et al., 2000). The first contradicts the assumptions that there is a need to change from a process exchange model to a system that supports the use of concurrent engineering (CE) principles (Common *et al.*, 2000). The second has been identified by many researchers as a traditional „push-system approach" that creates waste (Howell & Ballard, 1994; Tommelein, 1998; Yang & Ioannou, 2001). That is because the critical path method (CPM) possesses various deficiencies in scheduling repetitive projects and neglects the important of production information, such as production rate and work location (Yang & Ioannou, 2001; Rooke *et al.*, 2007b).

However, the framework mentioned above is considered to be no longer adequate due to the vast progress made among the lean construction community since the study was carried out (Johansen & Walter, 2007). Consequently, Johansen & Walter (2007) developed a new conceptual framework to comprise eight areas: Management, Planning/Control, Behaviour, Supply, Installation, Design, Collaboration, and Procurement. This framework was only used to test the range and dissemination of *lean* concepts among construction companies in Germany. Therefore, it will be adopted and modified by the author for evaluating LC, as practiced in the UK (Section 2.6).

In another study, Johansen & Porter (2003) considered how the Last Planner methodology could be applied to the UK building construction. This included the use of LPS, look-ahead

schedules, analysis of percentage Plan completion (PPC) on the weekly targets as the main metric and involving clients, designers and subcontractors in initial planning. The methodology had some success in terms of improving structure and control in planning, but there were structural and cultural barriers identified which need to be addressed before it can be fully successful in the UK. According to Johansen & Porter (2003), there seemed to be a cultural issue in getting the subcontractors to adopt the methodology in a comprehensive way. For instance, some subcontractors actively avoided carrying definite aspects of responsibility themselves; this was due to commercial pressure and because of their over-confidence in their relationship with the main contractor (Johansen & Porter, 2003b). These cultural and structural barriers will be discussed in more depth in the next section.

An important point to stress is that there seems to be an issue on how to interpret the „no blame" culture of the LPS that occurs on the weekly representations of the PPC charts. It was noticed that some subcontractors would only agree to unchallenging weekly targets, in order to give themselves an easy time and avoid being blamed (Johansen & Porter, 2003b). The author suggests that the LPS may need to be updated, so that the PPC chart represented weekly would show the total integrated results of the whole team instead of showing individual results. In a discussion with Mr. Alan Mossman on the LCI-UK network on LinkedIn, he accepted this suggestion:

> *"That is the recommended approach. A construction site is a system. The system elements are interdependent - they affect each other so measuring the commitment reliability (that is what PPC does) of one part of the system without considering the effects of the commitment reliability of other system elements is unfair, unreasonable & unjust. PPC is information; it is an indicator and an output of the total system. I believe it is dangerous to use it as a target - PPC is too easy to manipulate"*[1].

Alternatively, there are some other case studies with varying levels of success across the UK (BRE, 2011). Also, there seems to be good prospects ahead for applying LC concepts to the UK roofing and cladding industry (Swain & Mossman, 2003).

It is obvious that *lean* is happening in construction in the UK. There are just a number of barriers militating against successful lean implementation (Mossman, 2009). Therefore, this study will focus on identifying the barriers that may prevent the successful implementation of LC in UK; the author will proceed to propose a strategy for overcoming the barriers identified.

2.4 Barriers to the Successful Implementation of Lean Construction

Several studies have been carried out in different countries worldwide to identify the barriers in implementing the LC approach. Some of these studies focused on investigating barriers that prevent the diffusion and implementation of LC (Johansen & Walter, 2007; Olatunji, 2008; Senaratne & Wijesiri, 2008; Abdullah *et al.*, 2009; Mossman, 2009). Others focused on identifying barriers that exist during the execution of LC practices (Seymour, 1998; Garnett, 1999; Alarcon *et al.*, 2002; Johansen & Porter, 2003b; Jørgensen *et al.*, 2004; Alarcón *et al.*, 2005; Ansell *et al.*, 2007).

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[1] A reply from Mr. Alan Mossman on the author‟s suggestion posted in a topic named: „Needing help for a better understanding of LC implementation‟ created by the author on the LCI-UK Network on LinkedIn. Find more discussions at http://www.linkedin.com/groups?about=&gid=1179447&trk=anet_ug_grppro.

In a research by Bashir *et al.* (2010) these barriers were classified into six different categories: Management issues, Technical issues, Educational issues, Financial issues, Governmental issues, and Human attitudinal issues. Based on a careful and comprehensive literature review relating to the barriers in implementing the LC approach, this study classifies barriers to the successful implementation of LC into twelve different categories, as will be shown below.

2.4.1 Lack of commitment to change and continuous improvement

The construction industry has rejected before many ideas from manufacturing because of the belief that construction is different; that is as projects in construction are one-off project based, more complex and take place under lots of uncertainties and constraints (Salem *et al.*, 2006). There is a repeated claim that the construction industry is very different than manufacturing because every product is unique. Egan (1998) does not agree with that claim because he believes that the construction industry includes lots of repeated processes. The task force suggests that the construction industry has two options: *"to ignore all this in the belief that construction is so unique that there are no lessons to be learned; or seek improvement through re-engineering construction, learning as much as possible from those who have done it elsewhere"* (Egan, 1998). Koskela (2000) also, believes that all of these barriers are just temporary; they may slow down the diffusion but will not impede it.

2.4.2 Fragmentation and subcontracting

Many similar factors in the construction industry of both developed and developing nations, act as an obstacle to the adoption of LC concepts (Forbes *et al.*, 2002). In both arenas, fragmentation and subcontracting in construction hinder the incentive for project participants

to cooperate and learn together (Mossman, 2009). These participants have different circumstances and priorities but with one shared objective of successfully completing the related project (Abdullah *et al.*, 2009). Therefore, it is essential to establish effective communication between all parties by embarking on the partnering and integrated team-working route (Thomas & Thomas, 2005). That is because, in the process of implementing the LC concepts, poor communication will have a negative impact on the effectiveness of the project delivery and coordination system (Abdullah *et al.*, 2009).

Also, in construction projects, contractors traditionally hire subcontractors. These subcontractors generally do not have contracts with the client; and may sometimes have to work with insufficient budgets, even if the client pays a fair price to the main contractor (Forbes *et al.*, 2002). As a result, this often leads to compromised quality of work. Although, some clients have tried to overcome these barriers by providing framework opportunities and partnering contracts, these usually only involve the main participants (Mossman, 2009).

2.4.3 Procurement and contracts

Traditional Procurement methods and contracts undermine the application of lean principles; because they seem to create adversarial relationships between parties involved (Mossman, 2009), and can add waste to the process (Cullen *et al.*, 2005). According to Cullen *et al* (2005), contract forms that allow one party to impose power over another create adversarial relations. These adversarial relations create transaction costs which are considered waste, and are thus opposing to the lean philosophy. Mossman (2009) suggests that recent contracts such as PPC2000, Be, NEC3, and the new JCT-Constructing Excellence Contract are moving in the *lean* direction.

In addition, Johansen and Walter (2007) stated that any procurement form that tends to delegate design work to external designers, separates the design from the construction process; and therefore misses the *lean* aim of collaboration and integration. Therefore, selecting a collaborative procurement system with a significant emphasis on concurrent design and construction, would be recommended for the successful implementation of LC (Common *et al.*, 2000).

2.4.4 Culture and human attitudinal issues

Applying Lean thinking principles into the construction industry requires a fresh approach in thinking about the complete process; in order to remove „waste", create „continuous flow", and radically enhance „value" to the customer. On contrast, the culture of the UK construction industry is known to be opportunistic, prone to conflict and resistant to change (Rooke *et al.*, 2003; Rooke *et al.*, 2004). Therefore, changing traditions and behaviour seems to be a necessary prerequisite for implementing LC in the UK (Seymour, 1998; Garnett, 1999; Common *et al.*, 2000). Based on researches and case studies conducted by Common *et al.* (2000), Alarcon *et al.* (2002), Johansen and Porter (2003), Johansen *et al.* (2004), Jorgensen *et al*. (2004), Alarcon *et al*. (2005), Salem *et al.* (2006), Olatunji (2008), Abdullah *et al* (2009), and Mossman (2009), these factors include: lack of commitment, lack of ability to work in group, lack of self criticism, weak communication and transparency among teams of the production process, cultural issues in getting the subcontractors and workers to adopt the methodology in a comprehensive way, fear of taking risk, wrong attitude to change, not viewing housekeeping as a continuous effort, lack of team spirit among professionals, over-enthusiastic champions, dependency, lack of incentives and motivation, lack of trust, and fear of blame and contractual disputes.

2.4.5 Adherence to traditional management concepts due to time and commercial pressure

One of the main barriers to the successful implementation of LC is the tendency of construction firms to apply traditional management concepts as opposed to productivity and quality initiatives (Abdullah *et al.*, 2009). According to Common *et al.* (2000), it seems that commercial pressure to do the deal takes place over production issues. For that reason, Mossman (2009) advises companies not to wait for a crisis to make efforts to change; because it would be then too late to learn news skills and new ways of thinking. Consequently, Abdullah *et al.* (2009) stresses that if construction firms keep stuck to their current management concepts, as they are satisfied with achieving their intended objectives, they will become reluctant to any changes even though these changes may be able to improve their performance and increase their quality and productivity rates.

2.4.6 Financial issues

The successful implementation of LC requires adequate funding to provide relevant tools and equipments, sufficient professional wages, incentives and reward systems; investment in training and development programmes, and perhaps employing a lean specialist to provide guidance to both employers and employees during the initial implementation (Bashir *et al.*, 2010).

Studies conducted by Dulaimi and Tanamas (2001), Olatunji (2008), and Mossman (2009) have revealed some common financial barriers that need to be carefully addressed. These include: inflation, inadequate funding of projects, unstable markets for construction, lack of basic sociable amenities required for facilitating the lean implementation, lack of incentives

and motivation, low professional remuneration, unwillingness of some companies to invest extra funds to provide training for their workers more than the essential legislation requirement.

2.4.7 Predominance of final-based solutions in the thinking of managers and professionals in construction

Rooke *et al*. (2007) emphasised that the most successful production management solutions are flow based ones; and that adherence to substance thinking poses a significant barrier to achieving progress in the construction industry.

An example of this in the UK, is the use of bills of quantity (BoQ) based on the Civil Engineering Standard Method of Measurement (CESSM). That is because there are two problems that exist with CESSM based bills. First, aggregating the BoQ items into self-contained construction operations is done by client representives and may not match the way the contractor intends to do the works (Hoare & Broome, 2001). Second, lack of transparency in the way that prices are made up as to the contractor‟s assumptions about profit and quality of work (Rooke *et al.*, 2007a).

Those two problems mentioned above could lead to price variations and delivery difficulties. Therefore, the use of claims management could be recommended. Even though it is argued that contractors tend to use more effort on gaining profit from claims than from improved construction methods, tackling the claims culture could be an important step towards increasing productivity, and providing conditions in which LC would be successfully implemented (Rooke *et al.*, 2003; Rooke *et al.*, 2004).

Another alternative supported by Hoare & Broome (2001) could be replacing the BoQ with the activity schedule included in the Engineering and Construction Contract (ICE, 1998). According to Rooke *et al.* (2007) this method of mesurement involves pricing activities rather than quantities, thus allows price to be more closely linked to the actual process of costruction. They consider both: the activity schedule and claims planning as examples of flow metaphysics, as opposed to the CESSM which is idenified as an object metaphysics by them.

2.4.8 Lack of top management commitment and support

The successful implementation of LC or any new innovative strategy needs to be supported by top management. Top managers have to provide sufficient time and resources to develop an effective plan, and manage changes arising from the implementation process (Bashir *et al.*, 2010). Although studies carried out by Abdullah *et al*. (2009), and Alinaitwe (2009) have identified lack of top management leadership and commitment as a main barrier to the implementation of LC, Mossman (2009) believes that the problem exists with middle management not top mangement. For middle managers the benefits are not very clear and their training and experience is not sufficient to provide them with the ability to manage change in thinking, responsibility and roles (Mossman, 2009). Alternatively, benefits for top mangement from imlementing LC concepts are very clear: increased productivity, reduced time and accidents (Mossman, 2009). However, several studies reported various management related issues such as: poor planning, lack of delegation to enhance work flow, poor understanding of customer needs, lack of a participative management style for the workforce, logistics‟ problems, absence of look-ahead planning and poor coordination (Shammas-Toma *et al.*, 1998; Johansen & Porter, 2003b; Olatunji, 2008; Alinaitwe, 2009).

2.4.9 Design/construction dichotomy

Design and planning are identified as major attributes of the process of LC. Any ignorance to the importance of these could lead to disastrous loss of time, cost and the overall process (Common et al., 2000). Due to traditional contractual procedures, design and implementation of design are treated as separate products (Rooke *et al.*, 2007a). This causes a conflict border between the two phases and creates lots of waste such as: incomplete and inaccurate designs, rework in design and construction, lack of buildable designs, final products with significant variation from values specified in the design, and disruption to contractors due to design changes made by designers (Shammas-Toma *et al.*, 1998; Rooke *et al.*, 2007a).

According to Seymour and Rooke (2000) designers usually ignore the production conditions in which their designs will be implemented. There is an argument on how to solve uncertainties of work on site and on how quality could be achieved. Some view the attainment of quality as a factor of relationships and good coordination, while others see it as a matter of strict adherence to specifications and codes (Shammas-Toma *et al.*, 1998).

A suggested solution to this design/construction dichotomy could be the use of the British Standard (BS) 5606:1990 (Seymour & Rooke, 2000; Rooke *et al.*, 2007a). The BS 5606 provides a formula for site personnel to calculate the consequences for the achievement of specified tolerances. Also, designers can make adjustments in their specifications to code recommendations if they anticipate circumstances on site that will make strict adherence to the code difficult or impossible. However, this still requires good collaboration and coordination between the two parties, and is subject to the multiple vagaries of inter-personal relations on site (Seymour & Rooke, 2000; Rooke *et al.*, 2007a).

Another suggestion by Shammas-Toma *et al.* (1998) is giving the contractor the responsibility for the re-inforcement detailing. According to them, designers themself acknowledged their limitation in producing buildable reinforced concrete designs; where poor detailing can account for about 20% of reinforcement which in turn is about 25% ofthe contract. This suggestion may lead to improved constructability, and gives the contractor some control during the design phase; this involvement could also encourage the takeup of D&B contracts (Shammas-Toma *et al.*, 1998).

However, One Promising aspect is the tendency in the construction industry to adopt integrated design to enhance performance and add value to the final products. There are two opposing views regarding the way to adopt traditional design practices to the new trend of work (Forgues & Koskela, 2009). Promoters of sustainable construction hypothesize that it is a matter of developing from a sequential to an iterative design process; but the British government argues that a change to the context in which the design is realized is essential and requires a change in how projects are procured (Forgues & Koskela, 2009). Findings by Forgues and Koskela (2009) demonstrated that: problems with integrated design team efficiency are related to context and not process, traditional procurement processes strengthen socio-cognitive barriers that hinder team efficiency, and new collaborative procurement approaches help to mitigate socio-cognitive barriers and improve integrated design team performance.

2.4.10 Lack of adequate lean awareness & understanding

Lean thinking principles have been adopted from manufacturing sectors to the construction industry (Eriksson, 2009). Therefore, many LC principles and techniques are referred to those contained within lean manufacturing. However, there is a debate on the extent to which

methods of lean production are applicable to LC (Green, 1999a; Green, 1999b; Howell & Ballard, 1999; Green, 2000). Some lean production measures may not be equally applicable in construction and may need to be amended (Eriksson, 2009). Abdullah *et al.* (2009) suggests that it is essential to have a full comprehension about lean manufacturing concepts in advance, in order to be able to clearly understand the concept of LC.

Also, many studies have reported the lack of exposure on the need to adopt LC, and difficulties in understanding its concepts to be significant barriers to the successful implementation of LC (Johansen *et al.*, 2002; Johansen & Porter, 2003a; Ansell *et al.*, 2007; Abdullah *et al.*, 2009). This could be due to the lack of a shared and agreed definition or understanding of what is meant by *lean* (Green, 1999a; Jørgensen & Emmitt, 2008; Mossman, 2009). Eriksson (2009) does not agree with that because he believes that the definition and understanding of LC, as for other innovative management practices like partnering, would be best developed by investigating its core elements.

In addition, LC has introduced to the construction industry the usage of new tools and techniques, which have a distinct difference when compared to those used in traditional practices. According to Abdullah *et al*. (2009) these differences have to be clearly understood in order for them to be optimally utilised. However, several researchers believe that *lean* is more than tools or techniques; instead it requires a transformation in thinking, collaboration, flexibility, commitment, discipline, and a broad system-wide focus (Rooke *et al.*, 2007a; Mossman, 2009; Terry & Smith, 2011). Lean has to be implemented across the business and value chain to deliver the promised results; any isolated efforts may even cause waste (HA, 2009b).

A study by Common et al. (2000) revealed that there is a considerable lack of understanding to the fundamental concepts and application of lean within UK construction companies. For instance, a minority of respondents considered that the lean concept is not suitable for the construction industry because of the demands from clients for quicker and cheaper projects. This is inconsistent with the principles of *lean* of eliminating waste to reduce time and cost, and add value to the client.

Also, many companies that professed to be applying LC principles seemed to combine traditional techniques with those that are considered *lean*. A typical combination was the use of traditional contracting, critical path planning and SCM. Although SCM and partnering are important attributes to the successful implementation of LC, the use of traditional contracting and critical path planning (CPP) hinders their effects. That is because both traditional contracting and critical path planning have been identified as contributors of waste in construction (Common et al., 2000; Johansen & Walter, 2007). Furthermore, only a few companies recognized the importance of design and planning to the process of LC.

2.4.11 Educational issues

Although there have been several efforts to provide awareness and guidance to LC by researchers, academics, practitioners and professional bodies in the UK and some other countries, it seems that educational barriers could pose a great threat to the sustainable implementation of LC (Bashir *et al.*, 2010).

Some of these barriers include: lack of technical skills, ignorance to human resource management and development, inadequate training, poor understanding and awareness, poor team-work skills, illiteracy and computer illiteracy (Green, 1999a; Alarcon *et al.*, 2002;

Johansen & Porter, 2003b; Jørgensen *et al.*, 2004; Olatunji, 2008; Abdullah *et al.*, 2009; Mossman, 2009).

2.4.12 Lack of customer-focused and process-based performance measurement systems

There is an industry tendency to measure performance in terms of time, cost and meeting code; but very limited consideration has been subjected to client satisfaction (Forbes *et al.*, 2002). These traditional performance prefrences measured in projects, specifically costs and schedule, are not appropriate for continuous improvement because they are not effective in identifying the root-causes of quality and productivity losses (Alarcon & Serpell, 1996). This issue will be discussed comprehensively in the following section.

2.5 How to Evaluate the Effect of Barriers on the Successful Implementation of Lean Construction?

The implementation of LC needs to be appropriately managed and controlled to increase the chances of success (Alinaitwe, 2009). In some countries, the application of lean principles to construction has not been successful due to the many barriers to its successful implementation (Alinaitwe, 2009). These barriers could affect the application process of LC, hinder the project performance, and lead to disastrous results if not properly managed (Alinaitwe, 2009). By not understanding the factors that affect the successful implementation of LC, organizations will not be able to know what improvement efforts need to be made, where these efforts should be focused, or which efforts could obtain best results (Leong & Tilley, 2008). For this reason, this study will conduct a thorough investigation of the

performance measurement systems that could be used to control and evaluate the effect of barriers on the successful implementation of LC.

2.5.1 Project performance measurement and benchmarking

The use of simple and well-designed performance measurements and procedures is very important to achieving proper managing, control, and evaluation of variations and improvements (Alarcón & Serpell, 1996). That is because performance measurement provides the information required for process control, and makes it feasible to set up challenging goals (Lantelme & Formoso, 2000; Moon *et al.*, 2007). It is also necessary to support the successful implementation of business strategies (Lantelme & Formoso, 2000), such as the application of LC. Correspondingly, benchmarking allows managers to constantly improve processes and compare their existing performances against others that expertise in such processes elsewhere. Neely *et al.* (1996) define performance measurement as „*the process of quantifying effectiveness and efficiency of action* ". Effectiveness is the extent to which a target is achieved (e.g. client satisfaction) with resources applied (Neely et al., 1996; Cheng et al., 2009). Efficiency is the evaluation of how economically the resources are utilised to meet client requirements (Neely *et al.*, 1996).

Without the use of appropriate performance measurement systems (PMSs), it becomes very difficult for organizations to understand why poor performance continues, or how improvement could be achieved (Leong & Tilley, 2008). Also, without PMSs, managers cannot know whether they will be able to achieve their objectives and goals or not (Neely *et al.*, 1996). According to Chrysostomou (2000) „*to manage you must measure, if you don't you are only practising*"; cited in Alarcón *et al.* (2001). This points out that the selection of

appropriate measures has a major influence on the implementation of strategies, and is essential for the development of improvement programmes (Lantelme & Formoso, 2000).

2.5.2 Project performance measures

Traditional Performance measurement systems are based on financial measures (Lantelme & Formoso, 2000; Suwignjo *et al.*, 2000). The latter are result-oriented performance indicators, and have been strongly criticised by many researchers (Alarcón *et al.*, 2001; Mitropoulos & Howell, 2001; Takim & Akintoye, 2002; Costa *et al.*, 2004; Moon *et al.*, 2007; Nudurupati *et al.*, 2007; Leong & Tilley, 2008). That is because these parameters are backward focused (Lantelme & Formoso, 2000). They are not measured until project is complete; and thus the information obtained arrives too to take any corrective actions (Alarcón & Serpell, 1996; Moon *et al.*, 2007). As a result, these outcome based indicators cannot be used to identify barriers or problems that exist during the execution of processes. According to Alarcón *et al.* (2001) traditional control systems focus their attention in conversion activities and ignore flow activities; therefore nearly all non value-adding activities become invisible.

Instead, Costa et al (2004) recommends the use of leading measures aiming to give early warnings, identify barriers and potential problems, and emphasize the need for future investigation. This recommendation is supported by Neely *et al.* (1996) who asserted the need to adopt formal process based approaches. Also, it is important to use measures for tracking improvement not reporting (Terry & Smith, 2011). Measurement alone is not enough; it is essential to analyse these indicators with the objective to detect the problems and their root causes (Alarcón *et al.*, 2001). This approach enables managers to identify strong and weak areas, and thus make more effective decisions (Figure 2.1).

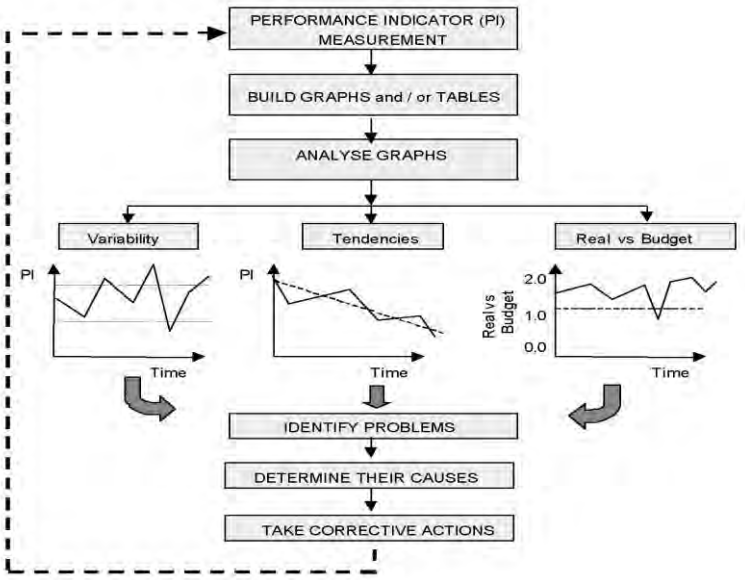


Figure 2.1: How performance indicators support management actions (Grillo, 1997), adopted from Alarcón *et al.* (2001)

Grillo (1997), cited in Alarcón *et al.* (2001), proposed a model that shows how that different processes, variables and decisions that interact during a project execution influence the result of a project (Figure 2.2). Based on this figure below, performance indicators were classified into three different types (Alarcón *et al.*, 2001) :

- Results: indicators to measure the level of success that a project has achieved, at the end of a project (e.g. cost and schedule deviations).
- Process: indicators that have the objective of measuring processes that occur throughout the project such as: procurement, design, planning and construction.
- Variables: these are decisions, strategies, and others that are not process indicators but have an effect on the performance of the project (e.g. types of contract, subcontractor ratio).

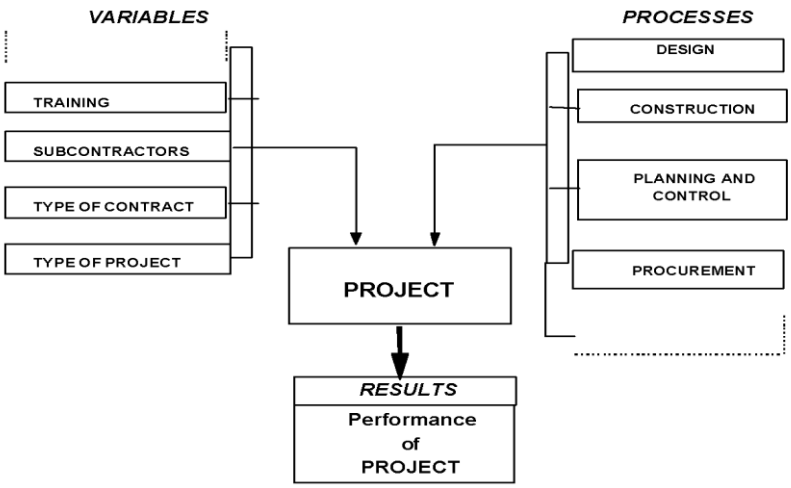


Figure 2.2: Performance indicators (Grillo, 1997), adopted from Alarcón *et al.* (2001)

The model mentioned above seems consistent with the behavioural-performance-outcome (B-P-O) cycle, which is well established in industrial psychology for evaluating performance, and examining how people formulate goals and perceive outcomes (Liu & Walker, 1998). The B-P-O cycle was then extended and modified by Liu & Walker (1998) to include goals and evaluation, as shown in Figure 2.3.

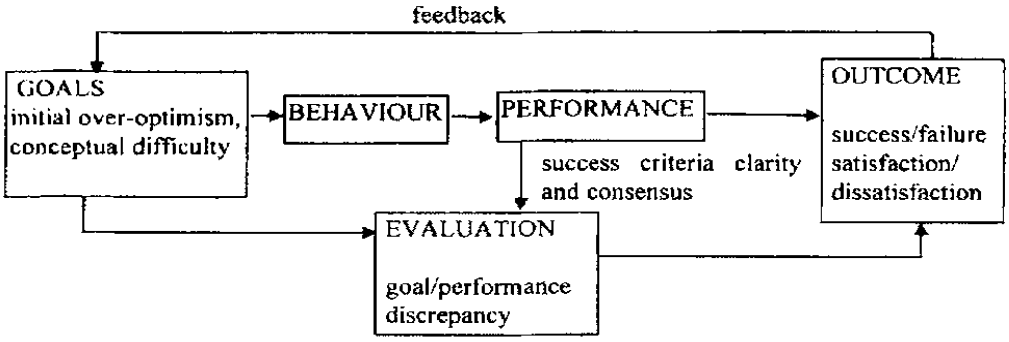


Figure 2.3 Factors that effect project success, adopted from Liu & Walker (1998)

Liu and Walker (1998) stress that it is important to understand how goal-directed behaviour influences performance, and further leads to an outcome which is then evaluated by the individual‟s perception. Here, the effect of barriers or factors that influence performance

could be evaluated by the relationship between the realised performance level and the expected performance (goal) level; where clarity of success criteria and consensus are vital for the evaluation process to take place at each level successfully (Liu & Walker, 1998).

2.5.3 Key performance indicators (KPIs) in the UK

In order to help organisations move towards best practice in response to the Egan‟s report (1998), the UK working groups on KPIs identified a set of non-financial parameters for benchmarking projects (Takim & Akintoye, 2002; Sikka *et al.*, 2006). These KPIs are classified into three levels, namely, headline, operational, and diagnostic (Costa *et al.*, 2004; Nudurupati *et al.*, 2007). The KPI groups and their associated indicators are shown in the Table 2.1 below. Headline indicators provide a measure of the overall health of a firm. Operational Indicators bear on specific aspects of a firm‟s activities and should enable management to identify and focus on specific areas for improvement. Diagnostic Indicators provide information on why certain changes may have occurred in the headline or operational indicators and are useful in analysing areas for improvement in more detail (The KPI Working Group, 2000).

Despite the initiatives of the KPI programme, there are some problems identified in the KPIs. For instance, none of the measures mentioned could identify the performance of suppliers in a project environment (Takim & Akintoye, 2002; Costa *et al.*, 2004). Also, there are no suggestions for performance indicators in benchmarking projects at the project selection phase, such as the analysis stage (Takim & Akintoye, 2002). For this reason, Takim & Akintoye (2002) suggests that the successful construction project performance can be devided along three orientations: procurement, process, and results oriented. A similar

approach was adopted by Sikka *et al*. (2006) who classified KPIs into three conceptual phases of a construction project: pre-construction, construction, and post-construction; as they believe that project success criteria change with time in each phase.

Table 2.1: KPIs groups and levels (The KPI Working Group, 2000)

Group	Indicators	Level
Time	1. Time for Construction	Headline
	2. Time Predictability – Design	Headline
	3. Time Predictability – Construction	Headline
	4. Time Predictability – Design & Construction	Operational
	5. Time Predictability – Construction (Client Change Orders)	Diagnostic
	6. Time Predictability – Construction (Project Leader Change Orders)	Diagnostic
	7. Time to Rectify Defects	Operational
Cost	1. Cost for Construction	Headline
	2. Cost Predictability – Design	Headline
	3. Cost Predictability – Construction	Headline
	4. Cost Predictability – Design and Construction	Operational
	5. Cost Predictability – Construction (Client Change Orders)	Diagnostic
	6. Cost Predictability – Construction (Project Leader Change Orders)	Diagnostic
	7. Cost of Rectifying Defects	Operational
	8. Cost In Use	Operational
Quality	1. Defects	Headline
	2. Quality Issues at Available for Use	Operational
	3. Quality Issues at End of Defect Rectification Period	Operational
Client Satisfaction	1. Client Satisfaction Product – Standard Criteria	Headline
	2. Client Satisfaction Service – Standard Criteria	Headline
	3. Client Satisfaction – Client-Specified Criteria	Operational
Change Orders	1. Change Orders – Client	Diagnostic
	2. Change Orders – Project Manager	Diagnostic
Business Performance	1. Profitability (company)	Headline
	2. Productivity (company)	Headline
	3. Return on Capital employed (company)	Operational
	4. Return on Value Added (company)	Operational
	5. Interest Cover (company)	Operational
	6. Return on Investment (client)	Operational
	7. Profit Predictability (project)	Operational
	8. Ratio of Value Added (company)	Diagnostic
	9. Repeat Business (company)	Diagnostic
	10. Outstanding Money (project)	Diagnostic
	11. Time taken to reach Final Account (project)	Diagnostic
Health and Safety	1. Reportable Accidents (inc fatalities)	Headline
	2. Reportable Accidents (non-fatal)	Operational
	3. Lost Time Accidents	Operational
	4. Fatalities	Operational

2.5.4 Lean process measurement

Through the LPS methodology, project teams commit to complete assigned tasks in a given week. Some LC practitioners refer to percentage plans complete (PPC) as a metric for commitment reliability. According to Forbes & Ahmed (2011) a PPC value does not measure the level of utilization of a work flow (efficiency). Instead it measures production planning effectiveness and workflow reliability. Also, at each weekly meeting, time is given

to learn and understand why certain tasks were not completed as planned in the previous week, before creating a new weekly plan to be executed. The incompleted plans are studied and analysed to determine the barriers and root causes that affected the implementation process. The five-WHY analysis proceedure could be used for identifying the root-causes of problems; and a Pareto chart could be used for ranking the barriers and reasons for non-completion. Consequently, the information gained from the root-cause analysis would help the project teams to avoid obstacles in future work cycles, and improve the effectiveness and reliability of future work plans (Forbes & Ahmed, 2011).

Also, Moon *et al.* (2007) proposed a set of process-oriented performance indicators, which are derived from the TFV theory: reliability, efficiency and effectiveness. Furthermore, Alarcón et al. (2001) suggested a set of parameters that are „lean" based. The essence in their approach is to create a „measurement culture" within organisations that will facilitate future implementations. More lean performance measures are proposed by Forbes and Ahmed (2011).

2.5.5 Other approaches and methods

There are also some other approaches that could be used to design a PMS (that incorporates financial and non-financial measures), or to identify and evaluate the effect of factors/barriers on performance. Some of these are discussed below.

The balanced scorecard is a widely accepted framework (Nudurupati *et al.*, 2007). It was constructed to complement measures of past performance with measures of the drivers of future performance (Nudurupati *et al.*, 2007). Consequently, it links an organisation's strategy through a series of perspectives to KPIs (Fraser & Kelly, 2011).

Quantitative models for performance measurement systems (QMPMS) use cognitive maps, cause and effect diagrams, tree diagrams, and the analytic hierarchy process, to quantify the affect of factors on performance (Suwignjo *et al.*, 2000; Nudurupati *et al.*, 2007). There are three main steps in QMPMS: (1) identifying the factors that affect performance and their relationships; (2) structuring the factors hierarchically; (3) quantifying the effect of factors on performance (Suwignjo *et al.*, 2000; Nudurupati *et al.*, 2007). The quantification process is carried out based on the results of a pair-wise comparison questionnaire among the factors (subjective technique).

This approach for quantifying the affects of factors on performance could be criticised because it is subjective, and it may be difficult to be applied in practices. Suwignjo *et al.* (2000) do not agree with that previous assumption, because they believe that subject measurement is the only concept that is widely accepted in Multi-Criteria Decision Analysis to deal with multi-criteria problems. To clarify their idea further, they questionned the possibility of developing an objective measurement and scale to measure management committment, or to quantify objectively value trade-off between management committment and percent of reject. In order to overcome this argument, Suwignjo *et al.* (2000) propose the use of group judgement rather than individual to reduce the subjectivity of the judgement. However, one of the potential problems of this approach is that performance improvement usually involves identification of a large number of factors affecting performance. Consequently, the number of pairwise comparison questionnaire will be huge; and filling it in will be exhausting and time consuming (Suwignjo *et al.*, 2000).

Questionnaire model is possibly the most simple approach amongst all. It could be applied quantatively or qualitatively to obtain statistical or descriptive results. In a study to prioritise the LC barriers in Uganda‟s construction industry, Alinaitwe (2009) carried out structural

interviews with technical managers of building firms to assess their perception of the barriers to LC based on their experience at their firms. Using a questionnaire model and a data collection guide, the barriers were ranked twice. First according to the ease of overcoming each, then according to their influence on the implementation of LC. In this study, the author will carry out a similar approach which focuses on identifying and evaluating the effects of barriers on the successful implementaion of LC in the UK. This will help organisations in the construction industry to focus their attention and resources on the key issues.

2.6 A Framework for Evaluating LC, as Practiced in the UK

Building on the methodologies and conceptual frameworks used in earlier work in the UK (Common *et al.,* 2000), the Netherlands (Johansen *et al*., 2002), and Germany (Johansen & Walter, 2007), this study will carry out a similar survey among UK construction organisations to evaluate LC as practiced in the UK, discover the current awareness of lean principles & trends in lean development, and establish how lean concepts have been implemented and disseminated among construction organisations.

In their work Johansen & Walter (2007) identified eight areas as being fundamental attributes of a lean approach, as shown in Figure 2.4 below. However, there have been vast developments made among the lean construction community since the study by Johansen & Walter (2007) was carried out. Several recent studies have emphasised the importance of establishing a lean culture among the construction industry (Hines et al., 2011; Santorella, 2011; Terry & Smith, 2011). There has also been an improved understanding of the importance of using appropriate performance measurement systems (PMSs) to support the successful implementation of LC (section 2.5).

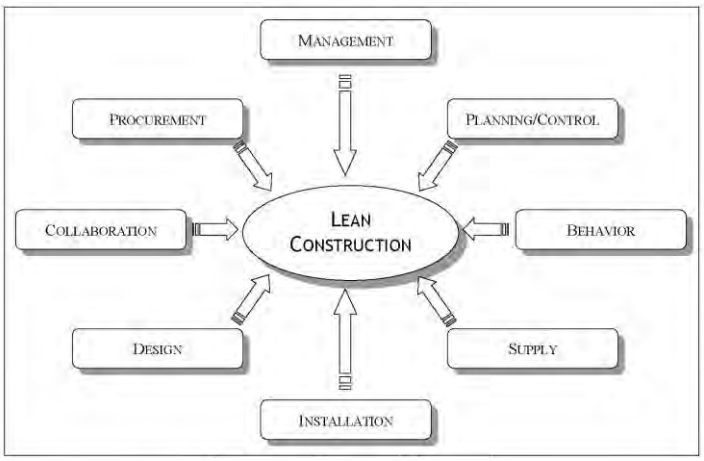


Figure 2.4: Conceptual Framework (Johansen & Walter, 2007)

Taking into consideration the progress of development in lean construction to date, the framework established by Johansen & Walter (2007) was modified by the author to include two main *lean* aspects: soft and hard, as shown in Figure 2.5. These two aspects incorporated nine areas which were recognized as being fundamental attributes of a lean approach. Within each area a number of tools/techniques were identified as they were seen as being influential for improving the lean conformance of construction organisations (Appendix A).

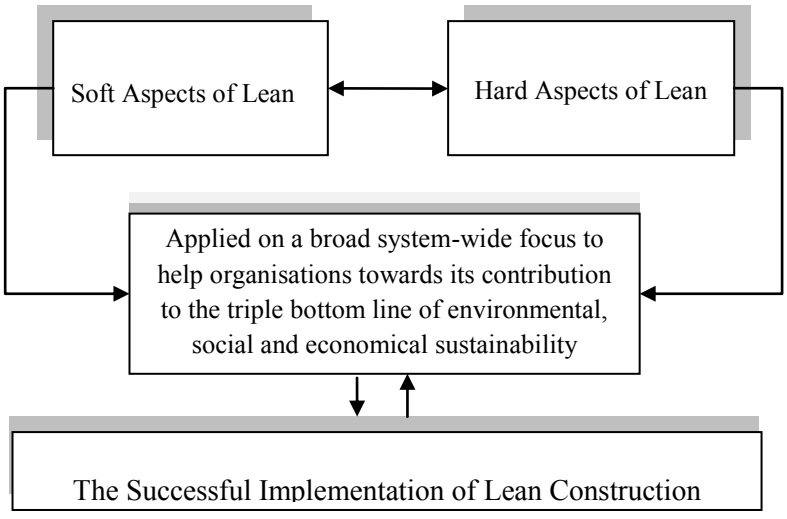


Figure 2.5: Modified Conceptual Framework (Author)

The 9 fundamental areas incorporated within the soft & hard aspects of lean are given in Appendix A

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

The literature review allowed the author to identify the gaps, glean ideas from others, and see results of related studies. However, in order to enable this study to be well-founded by its own findings and to allow comparisons to similar studies to be performed, independent research was conducted.

Research refers to a search for knowledge; it could be defined as a scientific and systematic search for significant information on a specific topic. In fact, research is an art of scientific investigation. According to Kothari (2009) the term 'reserach' refers to:

> *''The systematic method consisting of enunciating the problem, formulating a hypothesis, collecting the facts or data, analysing the facts and reaching certain conclusions either in the form of solutions(s) towards the concerned problem or in certain generalisations for some theoretical formulation''.*

The process of putting together a piece of good research is not something that could be done by just strictly following a set of rules about what is right and wrong. (Denscombe, 2007). In practice, the researcher faces a variety of options and alternatives and has to make his own strategic decisions about which to choose. There is no 'one right' direction to take, as each choice brings with it a set of advantages and disadvantages (Denscombe, 2007). There are, though, some approaches that are more appropriate for specific types of investigation and specific kinds of problems. According to Denscombe (2007), ''*the crucial thing for good*

research is that the choices are reasonable and that they are made explicit as part of any research report''. Furthermore, although all research is different, the following factors are common to all good pieces of research (White, 2006):

- The research is carried out in an unbiased fashion (bias - unfair preference or prejudice for one side of an issue). That means that all sides or alternative views of controversial issues should be presented;
- The research should be ethical and not harmful in any way to the participants;
- The research ensures data protection (confidentiality and anonymity).

This chapter describes the author's adopted research methodology. To see a comprehensive review on the different approaches used for conducting research, sources of data, data collection methods, and data sampling, please refer to Appendix 2.

3.2 Research Ethics

The research within this study required human participation to allow the perspective of the construction industry in the UK to be understood. An ethical review was undertaken in accordance with the University of Plymouth's guidelines to ensure that the research was not harmful to the participants in any way. The University of Plymouth takes very seriously the whole business of the ethics of research involving human participants. All staff and students of the University undertaking such research have to conform to a set of 'ethical principles', make these clear to those they are working with and ensure that they remain within them throughout the research. This process allowed the research to be conducted in such a way that would not affect the participant's professional or personal perception. In addition, this

research study included an information sheet for the participants, which illustrated clearly what the research was about, what it involved, and ensured data protection (Appendix 3).

3.3 Research Methodology Adopted

The choice of research methodology depends upon the set of research questions under consideration and the state of knowledge development (Pettigrew, 1990). In line with good research practice, the author has adopted a '*mixed methods'* approach involving a questionnaire and interviews. This approach is appropriate for the research aims of this project, some of which are very broad (e.g. evaluating LC as practised in the UK). For broader strategic issues, then a general quantitative survey method is needed to increase the generality of the findings; and questionnaires are most effective (Bryman, 2001). When investigating deeper then qualitative issues, particularly interviews are the most suitable (Thomas *et al.*, 2005). An outline of the research approaches adopted is illustrated below. This is divided into two parts. The 1st provides a detailed explanation to the data collection process (Figure 3.1 and Table 3.1). The second outlines the adopted data analysis methods, as well as the nature of the scale of measurements utilised.

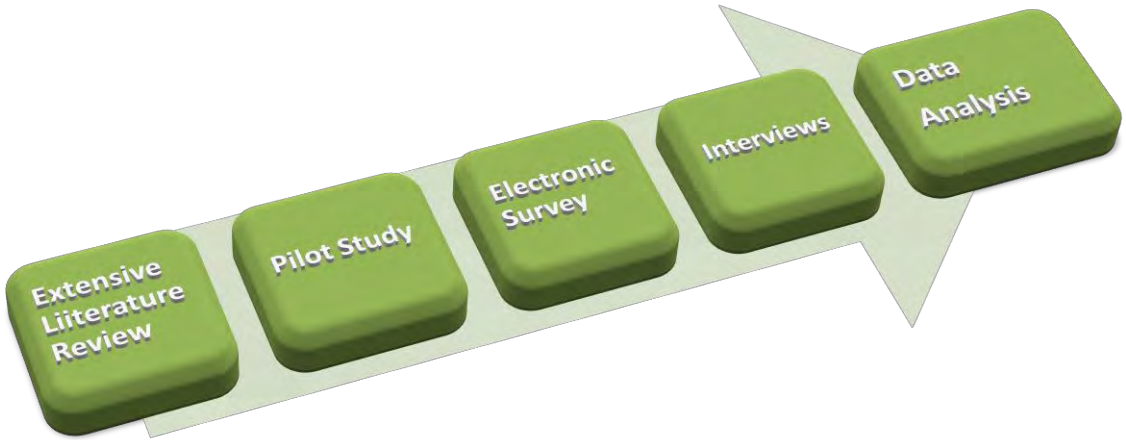


Figure 3.1: Data Collection process adopted for the research study (Author)

Table 3.1: Mixed methods approach adopted for the study (Author)					
	Data Collection Source	**Form**	**Type**	**Approach**	**Target**
1	Extensive Literature Review	N.A	Secondary	N.A	N.A
2	Pilot Studies (for the questionnaire)	Structured	Primary	Quantitative and Qualitative	5
3	Questionnaire (electronic survey)	Structured	Primary	Quantitative and Qualitative	100
4	Interviews (1 face to face + 2 webcam + 1 telephone)	Semi-Structured	Primary	Qualitative	4

3.3.1 Secondary data collection

To achieve the aims and objectives of the study an extensive literature review on LC was carried out. This enabled the author to have a holistic view to the subject, expand his knowledge, and identify gaps in literature related to the study. It also, allowed the author to understand the expected benefits from LC and the different key barriers to the successful implementation of LC. Based on an in depth analysis of these barriers, they were classified into 12 different categories. Also, for the purpose of the study, a conceptual framework for evaluating LC, as practised in the UK, was adopted and modified by the author. As means for an additional secondary data collection source, the author created a topic on the LCI-UK network on LinkedIn which received 75 comments up to date (Author, 2011). This enabled the author to engage in discussions with some of the top professionals and academics of the UK, and enhance his understanding of LC concepts & practices.

3.3.2 Pilot studies

Without piloting, the researcher can have no idea of how the questions will be understood by respondents, so will have difficulty understanding/interpreting the answers. Piloting is good research practice and is part of the research Plan-Do-Check-Act (PDCA) process (Lancaster *et al.*, 2004). Therefore, a number of pilot studies were conducted to ensure the clarity of the questions utilised in the survey. The outcomes of these pilot studies will be illustrated in Chapter Four.

3.3.3 Questionnaire (electronic survey)

After making amendments to the survey based on the feedback received from the pilot studies, the author launched the survey online at www.surveymethods.com on 5th August 2011. An electronic survey was adopted because of all of its advantages (See Appendix 2).

The targets of this survey were practitioners across the UK construction industry. A survey email invitation was sent to 198 professional practitioners in the UK construction industry. These participants were selected randomly from a number of professional groups, on LinkedIn web site, that almost represent all of the official professional organisations in the UK construction industry. These groups are the Institution of Civil Engineers (ICE), Royal Institute of British Architects (RIBA), Chartered Institute of Building (CIOB), Highway Engineers (HE) in the UK, and LCI-UK. The email invitation outlined the purpose of the study in terms of its aims and objectives, and offered the right to discontinue. Also, a topic which summarises the purpose of the study, and includes the link to the survey was created on each of these groups.

The survey was hosted online for nearly two weeks; and a total of 140 responses were received. The total takers through the email deployment status were 97 out of 198 invited participants. 10 out of the 198 were excluded as they were used for the pilot studies, thus reducing the number of invitations sent out to 188. This represents a response rate of 51.6% (nearly 52%). The percentage of the sample who participated in the study is an important factor in considering the validity and generalisability of the results. At least fifty percent of the sample is needed to participate if a response bias is to be avoided (Polit and Beck, 2006), as cited in Coughlan *et al.* (2007). On the other hand, the total takers through the web deployment status were 43. This brings the total survey takers to 140; hence a large sample size is used, this reduces the risk of sampling errors (Kothari, 2009). Also, more than half (61%) of the responses recieved were from practitioners with more than 10 years of experience holding senior positions at the directional and managerial level in their respective. This could also provide evidence for the validity of the sampling approach (Trochim, 2006a). A summary regarding the survey status is demonstrated in Figure 3.2.

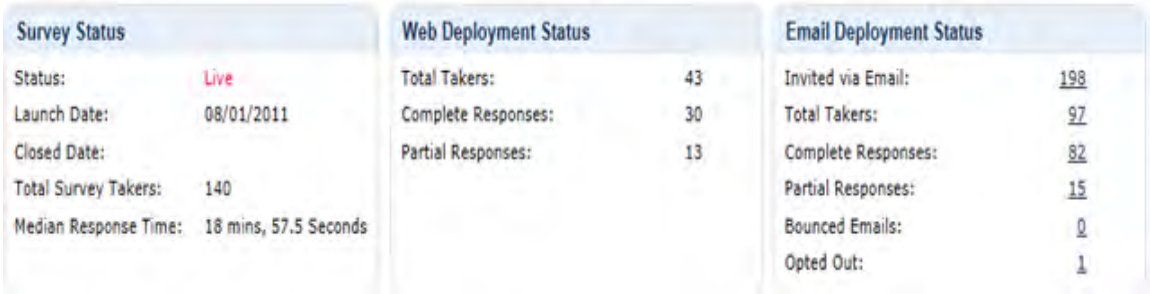


Figure 3.2: Survey dashboard summary (Author)

The design of the questionnaire emerged from the conceptual framework adopted and modified by the author (Appendix 1). This enabled the author to ensure that the questions are explicitly linked to the research questions, will collect accurate data, and will help achieve the

aims of the research. The questionnaire comprised a total of 36 questions. The break down structure of the questionnaire is shown in Table 3.2.

Table 3.2: Questionnaire Structure (Author)		
Contents and Focus areas	**Purpose**	**Q. No.**
Information sheet (Appendix 3)	To provide the participants with information regarding: • the purpose of the project; • The research ethics. This includes: informing consent, confidentiality and anonymity, right to discontinue, storage & publication of research material in accordance with University of Plymouth policies and procedure; • Project supervisor contact details for further information.	-
Background details	To gain information about the participants and their organisations, so it can be used for secondary analysis.	**1 - 9**
Soft aspects of Lean	To evaluate the participants' understanding of LC concepts and principles, and to evaluate the extent to which the Lean culture is established within organisations in the UK. Also to identify the techniques and tools used to facilitate the collaboration aspect of LC.	**10 - 17**
Hard aspects of Lean	To identify and evaluate the techniques, tools and methods used for the implementation of LC in the UK. These represent the 7 remaining corner stones of the conceptual framework, namely: Procurement, Management concepts, Planning and control, design, installation, supply, and performance measurement & evaluation.	**18 - 28**

Outcomes of the successful-implementation of LC	To test and evaluate the participants' realisation to the benefits of the successful implementation of LC. Also to identify some of the good practices executed by organisations, to help it contribute to the triple bottom line of environmental, social and economic sustainability. Finally to identify the reasons that could *'pull'* organisations to decide to go on the Lean journey.	**29 - 33**
Barriers to the successful implementation of LC	To see if the real world agrees with the author's identification of they Key barriers to LC in the UK. Also to prioritise the barriers identified, and evaluate its effect on the successful implementation of LC in the UK.	**34 & 35**
Invitation to Interviews	To ask for the participants' willingness to take part in follow-up interviews.	**36**
Strategy	Using the findings & analysis of the results to aid the author to propose a strategy for overcoming the significant barriers identified	**All**

3.3.4 Interviews

As mentioned previously (Table 3.1), semi-structured interviews were conducted to aid the author to investigate deeper. All of the interviewees volunteered to become a part of the research study. Although more than 40% of those who participated in the survey agreed to take part in the follow-up interview, only 4 professionals were selected. In Qualitative research, each individual is taken as a particular case and therefore large numbers decreases the detail and importance of each response. During the selection process, the author ensured that the participants represent the cases adopted for the secondary analysis (i.e. different:

roles, years of experience, level of education, size of organisations, turnover of organisations, & major clients). NVivo9 software program, available on University of Plymouth portal, was used to facilitate the transcription and analysis of the data collected through the interviews.

3.3.5 Data analysis

In most social research the data analysis involves three major steps. These are: data preparation, descriptive statistics, and inferential statistics (Trochim, 2006b). A summary of the different statistical approaches adopted for analysing the data is provided below in Table 3.3.

Table 3.3: Data analysis approach (Author)

Q. No.	Type of data	Statistics type adopted	Statistical approach
1 - 10	Nominal	Descriptive	Frequency distribution
11 - 14	Ordinal	Descriptive	Mode, Mean and Median
15	Nominal	Descriptive	Mode
16	Ordinal (5 Likert-scale)	Descriptive	Mode and Median
17	Nominal	Descriptive	Mode
18 - 27	Nominal	Descriptive	Mode
28	Ordinal (10 Likert-scale)	Descriptive	Mean
29 - 33	Nominal	Descriptive	Mode
34	Ordinal (5 Likert-scale)	Descriptive	Mode, Mean and Median
		Inferential	Cronbach's Alpha Test
35 & 36	Nominal	Descriptive	Mode

CHAPTER FOUR – RESULTS AND ANALYSIS

4.1 Introduction

In this chapter, the results of the data obtained through the pilot studies, electronic survey and the performed interviews are summarised, examined and analysed. Also, secondary analysis will be conducted to scrutinise the data obtained in more detail. This will allow trends and contrasting views to be determined; and thus more comprehensive findings to be concluded.

4.2 Pilot Studies

As mentioned previously in Chapter 3, piloting is good research practice and is part of the research PDCA process (Lancaster *et al.*, 2004). For this reason, a number of pilot studies were conducted to ensure the clarity of the questions utilised in the survey. The survey was sent to 10 professionals. Out of these ten, five professionals completed the survey (supervisor, academic professor, senior project controls engineer, graduate civil & coastal engineer, and an MSc postgraduate student). It is important to stress that none of these participants took part in the agreed final survey. The intention was to use only a small sample due to time constraints, and to leave more participants available for contribution in the main survey. For the purpose of the pilot study, an additional question was placed by the end of each page of the survey asking the participants for feedback on the clarity and relevance of the questions, in addition to the overall structure of the questions on each page. To see a summary of the feedback received, please refer to Appendix 4. These pilot studies helped to validate and improve the survey in terms of its format and structure, wording of statements & spelling mistakes, and the overall content. It also aided in choosing the most suitable and reliable measurement methods.

4.3 Questionnaire (Electronic Survey)

This survey received a total of 140 responses by professional participants in the UK construction industry. The average estimated time to complete the questionnaire was 15-20 minutes and it comprised of 36 questions. Only one question out of the 36 was mandatory, to enable academics with an industrial or construction management background to skip questions which may appear to be irrelevant to their current case. A total of 112 participants fully completed the questionnaire and 28 participants partially completed it. The median response time taken to complete the survey by all participants was 18 minutes and 57.5 seconds.

4.3.1 Background details: Questions 1-9

These set of questions were included to determine the nature and the background of the participants and their organisations. This data obtained was then used by the author to conduct the secondary analysis. A summary of the results obtained is provided below. To see the detailed analysis, please refer to Appendix 5.

Questions 1 to 5 were introduced to ask the participants about their profession, location, current role, qualification, and experience respectively. The responses obtained from these questions illustrated that more than half (63%) of the participants were from practitioners with more than 10 years of experience holding senior positions at the directional and managerial level in their respective. This enhances the validity of the sampling approach adopted (Trochim, 2006), and thus increases the reliability of the results achieved. Also, question 3 was introduced to ensure that all the participants of the survey were currently

involved in the construction industry, and thus had up-to-date first hand knowledge. The respondents represented a very wide range of professions. The largest proportion was for civil engineers (33.57%); followed by those who selected the 'other' option, which included a text box so they can enter their precise profession. This option was included within all questions for flexibility, and to obtain accurate description of the participants within the research study which is required so as to provide evidence to the generality of the findings. 77.14% of all participants were currently based in the UK and the others were based in a variety of international countries. Furthermore, most of the respondents were holding bachelors and masters degrees; where each of these groups had an equal representation of 35.71% of all the participants.

Alternatively, questions 6 to 9 were introduced to ask the participants about their organisations' size (number of employees), areas of operations, turnover, and major client respectively. The results of these questions indicated that this study was able to capture a very well distributed mixture of organisations, and included most of the largest construction organisations in the UK. Almost 30% of the responses were for organisations which their average annual turnover (AAT) exceeds 1000 Million UK sterling pounds, and 30.6% were for organisations which their AAT was between £100-1000 Millions. Alternatively 30% of the responses represented organisations which their AAT was from £1-10 Millions, and only 9.6% were for those which their AAT was from £10-100 Millions. Also, 53.62% of the responses were for organisations which have more than 500 employees. Furthermore, the results illustrated that the organisations involved in the study were engaged in very broad areas of operations. This was important to ensure that the results are not biased towards certain specific areas of operations. Finally, 60% of all respondents stated that their organisations' major clients/customers were 'both': public and private organisations (indicates no bias).

4.3.2 Secondary Analysis

Based on the large data sets collected from questions 1-9, secondary analysis was conducted on the rest of the questionnaire to help the author to investigate in more depth and provide a more detailed & accurate evaluation. For the purpose of the secondary analysis, six different classifications were established, as follows:

1. *Organisations' Average Annual Turnover (AAT) Classification* which included: small organisations (£1-100 Millions), medium organisations (£100-1000 Millions), and large organisations (£1000+ Millions). See Appendix 6.
2. *Organisations' Size Classification* which included: large organisations (more than 500 employees) and small organisations (less than 500 employees). See Appendix 7.
3. *Organisations' Major Client Classification* which included organisations dealing mainly with public clients, and those dealing mainly with private individuals & organisations. See Appendix 8.
4. *Years of experience Classification* which comprised of respondents with less than 10 years of experience (1-10), (10-20), and (20+). See Appendix 9.
5. *Level of Education Classification* which included: respondents holding NVQ & HNC/HND, Bachelors degree, and Masters degree (Appendix 10)
6. *Current Role Classification* which comprised of graduates/juniors, middle managers and senior managers (Appendix 11).

To have a 'holistic view' of the analysis of these six classifications (Overall secondary analysis), please refer to Table 4.1 in next page. To 'zoom in' and see the results and analysis of each classification separately, and with additional in-depth analysis supported by graphs and charts, see Appendices 6 – 11.

Table 4.1: Overall Secondary Analysis (Author)

Q.	Private Individuals and Organisations	Public Organisations	Turn Over [0-100]	Turn Over [100-1000]	Turn Over [1000+]	Organisations with less than 500 employees	Organisations with more than 500 employees	0-10 Years of Experience	10-20 Years of Experience	20+ Years of Experience	NVQ and HND/HNC	Degree	Masters	Graduates and Juniors	Team leader, site manager, and project manager	Regional manager, department manager, and managerial director	Academic/Researcher
10	· Yes= 68%	· Yes= 58.8%	· Yes= 60%	· Yes= 70.97%	· Yes= 71.43%	· Yes= 65.38%	· Yes= 66.13%	· 47.22% Yes	· 75.76 % Yes	· 72.73 % Yes	· 68.42% Yes	· 64.1 % Yes	· 68 % Yes	· 25% Yes	· 61.29 % Yes	· 76.67 % Yes	
11	· Mode= 1 · Median= 1 (Traditional) · Mean= 1.75	· Mode= 1 · Median= 2 (Learning) · Mean= 2.35	· Mode= 1 · Median= 1 (Traditional) · Mean= 1.7	· Mode= 1 · Median= 2 (Learning) · Mean= 2.32	· Mode= 1 · Median= 3 (Leading) · Mean= 2.63	· Mode= 1 · Median=1 (Traditional) · Mean= 1.6	· Mode= 1 · Median= 3 (Leading) · Mean=2.58	· Mode= 1 · Median= 1 (Traditional) · Mean= 2.138	· Mode= 1 · Median= 1 (Traditional) · Mean= 2.09	· Mode= 1 · Median= 1 (Traditional) · Mean= 2.209	· Mode= 1 · Median= 3 (Leading) · Mean= 2.368	· Mode= 1 · Median= 1 (Traditional) Mean= 2.128	· Mode= 1 · Median= 2 (Learning) · Mean= 2.04	· Mode= 1 · Median= 1 (Traditional) · Mean= 1.83	· Mode= 1 · Median= 1 (Traditional) · Mean= 2.06	· Mode= 1 · Median= 2 (Learning) · Mean= 2.4	
12	· Mode= 3 · Median= 3 (Leading) · Mean= 2.54	· Mode= 2 · Median= 3 (Leading) · Mean= 2.76	· Mode= 3 · Median= 3 (Leading) · Mean= 2.75	· Mode= 3 · Median= 3 (Leading) · Mean= 2.84	· Mode= 2 and 3 · Median= 3 (Leading) · Mean= 2.79	· Mode= 3 · Median= 3 (Leading) · Mean= 2.75	· Mode= 3 · Median= 3 (Leading) · Mean= 2.79	· Mode= 3 · Median= 3 (Leading) · Mean= 2.78	· Mode= 3 · Median= 3 (Leading) · Mean= 2.65	· Mode= 3 · Median= 3 (Leading) · Mean= 2.837	· Mode= 1 · Median= 3 (Leading) · Mean= 2.368	· Mode= 3 · Median= 3 (Leading) · Mean= 2.92	· Mode= 2 · Median= 2 (Learning) · Mean= 2.58	· Mode= 2 · Median= 2 (Learning) · Mean= 2.67	· Mode= 3 · Median= 3 (Leading) · Mean= 2.63	· Mode= 3 · Median= 3 (Leading) · Mean= 2.87	
13	· Mode= 1 · Median= 2 (Learning) · Mean= 2.43	· Mode= 1 · Median= 2 (Learning) · Mean= 2.64	· Mode= 1 · Median= 2 (Learning) · Mean= 2.32	· Mode= 1 · Median= 2 (Learning) · Mean= 2.38	· Mode= 1 · Median= 2 (Learning) · Mean= 2.70	· Mode= 1 · Median= 2 (Learning) · Mean= 2.12	· Mode= 1 · Median= 2 (Learning) · Mean= 2.56	· Mode= 1 · Median= 2 (Learning) · Mean= 2.39	· Mode= 1 · Median= 2 (Learning) · Mean= 2.35	· Mode= 1 · Median= 2 (Learning) · Mean= 2.634	· Mode= 5 · Median= 3 (Leading) · Mean= 3.167	· Mode= 2 · Median= 2 (Learning) · Mean= 2.763	· Mode= 1 · Median= 1 (Traditional) · Mean= 1.92	· Mode= 1 · Median= 2 (Learning) · Mean= 2.4167	· Mode= 1 · Median= 2 (Learning) · Mean= 2.24	· Mode= 1 · Median= 2 and 3(Leading) · Mean= 2.77	
14	· Mode=1 · Median= 1 (Traditional) · Mean= 2.04	· Mode= 2 · Median= 2 (Learning) · Mean= 2.47	· Mode= 1 · Median= 1 (Traditional) · Mean= 2.02	· Mode= 1 · Median= 2 (Learning) · Mean= 2.22	· Mode= 1 · Median= 2 (Learning) · Mean= 2.38	· Mode= 1 · Median= 1 (Traditional) · Mean= 1.94	· Mode= 1 · Median= 2 (Learning) · Mean= 2.4	· Mode= 1 · Median= 1 (Traditional) · Mean= 2.05	· Mode= 1 · Median= 2 (Learning) · Mean= 2.096	· Mode= 1 · Median= 2 (Learning) · Mean= 2.357	· Mode= 3 · Median= 2 (Learning) · Mean= 2.33	· Mode= 1 · Median= 2 (Learning) · Mean= 1.71	· Mode= 1 · Median= 2 (Learning) · Mean= 2.12	· Mode= 1 · Median= 1 (Traditional) · Mean= 1.75	· Mode= 1 · Median= 2 (Learning) · Mean= 2.275	· Mode= 1 · Median= 2 (Learning) · Mean= 2.33	
15	1. Document Management Systems= 66.67% 2. Long-Term Contractual Agreements= 50% 3. Project Information Systems= 41.67% 4. Collaborative planning schedules= 41.67% 5. Cross functional teams= 33.33% 6. IPD= 20.83% 7. LPDS= 20.83% 8. All= 4.17% 9. Other= 0%	1. Long-Term Contractual Agreements= 70.59% 2. Cross-Functional Teams= 47% 3. Document Management Systems= 47% 4. Project Information Systems= 29.41% 5. Collaborative Planning Schedules= 29.41% 6. IPD= 23.53% 7. LPDS= 23.53% 8. All= 23.53% 9. Other= 5%	1. Long-Term Contractual Agreements= 59.09% 2. Document Management Systems= 52.27% 3. Collaborative Planning Schedules= 45.45% 4. PIS= 29.55% 5. Cross functional teams= 27.27% 6. IPD= 18.18% 7. LPDS= 9.09% 8. All= 6.82% 9. Other= 6%	1. Long-Term Contractual Agreements= 76.67% 2. Document Management Systems= 73.33% 3. Cross functional teams= 63.33% 4. PIS= 46.67% 5. Collaborative planning= 43.33% 6. IPD= 40% 7. LPDS= 23.33% 8. All= 23.33% 9. Other= 6%	1. Long-Term Contractual Agreements= 73.53% 2. Document Management Systems= 70.59% 3. Cross-Functional Teams= 61.76% 4. IPD= 47.06% 5. Collaborative planning= 44.12& 6. PIS= 41.18% 7. LPDS= 29.41% 8. All= 17.65% 9. Other= 8%	1. Long-Term Contractual Agreements= 56.86% 2. Document Management System= 54.9% 3. Collaborative Planning= 41.18% 4. Cross-functional teams= 31.37% 5. Project information Systems= 29.41% 6. IPD= 15.69% 7. LPDS= 11.76% 8. All= 9.8% 9. Other=3%	1. Long-Term Contractual Agreements= 76.27% 2. Document management Systems= 69.49% 3. Cross functional teams= 61.02% 4. Collaborative Planning= 44.76% 5. IPD= 47.46% 6. Project Information systems= 44.07% 7. LPDS= 25.42% 8. All= 22.03% 9. Other= 10%	1. Long term Contractual Arrangement= 62.86% 2. Document Management systems= 57.14% 3. Cross-Functional Teams= 37.14% 4. Collaborative Planning= 37.14% 5. Project Information Systems= 25.71% 6. IPD= 25.71% 7. LPDS= 20% 8. All=11.43% 9. Other= 5%	1. Long term Contractual Arrangement= 81.25% 2. Document Management Systems= 65.62% 3. Project Information Systems= 46.88% 4. Cross-Functional Teams=40.62% 5. Collaborative Planning= 40.62% 6. IPD= 28.12% 7. LPDS= 15.62% 8. All= 15.62% 9. Other= 9%	1. Document Management Systems= 64.29% 2. Long-Term Contractual Agreements= 61.9% 3. Cross-Functional Teams= 61.9% 4. Collaborative planning= 52.38% 5. IPD= 40.48% 6. Project Information Systems= 40.48% 7. LPDS= 21.43% 8. All= 21.43% 9. Other= 7%	1. Collaborative Planning= 72.22% 2. Long term Contractual Arrangement= 61.11% 3. Document Management systems= 55.56% 4. Cross-Functional Teams= 50% 5. IPD= 38.89% 6. Project Information Systems= 33.33% 7. LPDS= 22.22% 8. All=16.67% 9. Other= 11%	1. Long term Contractual Arrangement= 66.67% 2. Document Management Systems= 66.67% 3. Cross-Functional Teams=48.72% 4. Project Information Systems= 41.03% 5. Collaborative Planning= 38.46% 6. IPD= 28.21% 7. LPDS= 20.51% 8. All= 20.51% 9. Other= 5%	1. Long-Term Contractual Agreements= 70% 2. Document Management Systems= 57.5% 3. Cross-Functional Teams= 40% 4. IPD= 32.5% 5. Collaborative planning= 32.5% 6. Project Information Systems= 27.5% 7. LPDS= 15% 8. All= 15% 9. Other= 7%	1. Long term Contractual Arrangement= 63.64% 2. Document Management systems= 45.45% 3. Cross-Functional Teams= 27.27% 4. Project Information Systems= 27.27% 5. Collaborative Planning= 27.27% 6. IPD= 18.18% 7. LPDS= 18.18% 8. All=18.18% 9. Other= 0%	1. Document Management Systems= 75.86% 2. Long term Contractual Arrangement= 68.97% 3. Cross-Functional Teams= 41.38% 4. Project Information Systems= 34.48% 5. Collaborative Planning= 34.48% 6. IPD= 31.03% 7. All= 20.69% 8. LPDS= 10.34% 9. Other= 10%	1. Document Management Systems= 66.67% 2. Long-Term Contractual Agreements= 63.33% 3. Collaborative planning= 60% 4. Cross-Functional Teams= 56.67% 5. IPD= 46.67% 6. Project Information Systems= 43.33% 7. LPDS= 30% 8. All= 10% 9. Other= 6%	
16	Statements they should disagree/strongly disagree with: 1) 76% 2) 84% 5) 40% Statements they should agree/strongly agree with: 3) 80% 4) 64% 6) 20% 7) 44% 8) 92% 9) 83.34% 10) 72% 11) 92% 8 correct out of 11 Average score= 67.94%	Statements they should disagree/strongly disagree with: 1) 70.59% 2) 88.24% 5) 29.41% Statements they should agree/strongly agree with: 3) 82.35% 4) 70.59% 6) 29.41% 7) 29.41% 8) 100% 9) 70.59% 10) 76.47% 11) 88.23% 8 correct out of 11 Average score= 66.84%	Statements they should disagree/strongly disagree with: 1) 62.23% 2) 75.55% 5) 33.33% Statements they should agree/strongly agree with: 3) 64.45 % 4) 62.22% 6) 24.44% 7) 31.11% 8) 84.09% 9) 75% 10) 57.78% 11) 77.78% 8 correct out of 11 Average score= 58.9%	Statements they should disagree/strongly disagree with: 1) 86.67% 2) 90% 5) 30% Statements they should agree/strongly agree with: 3) 56.67% 4) 50% 6) 30% 7) 30% 8) 100% 9) 53.34% 10) 60% 11) 90% 8 correct out of 11 Average score= 61.51%	Statements they should disagree/strongly disagree with: 1) 76.47% 2) 82.36% 5) 41.17% Statements they should agree/strongly agree with: 3) 82.35% 4) 61.77% 6) 29.41% 7) 43.42% 8) 91.18% 9) 73.53% 10) 45.45% 11) 76.47% 7 correct out of 11 Average score= 63.96%	Statements they should disagree/strongly disagree with: 1) 67.3% 2) 76.92% 5) 32.69% Statements they should agree/strongly agree with: 3) 65.38% 4) 59.61% 6) 23.08% 7) 30.77% 8) 86.28% 9) 74.51% 10) 57.69% 11) 78.85% 8 correct out of 11 Average score= 59.37%	Statements they should disagree/strongly disagree with: 1) 76.27% 2) 86.44% 5) 33.89% Statements they should agree/strongly agree with: 3) 69.49% 4) 59.32% 6) 32.2% 7) 39.66% 8) 94.92% 9) 64.4% 10) 51.72% 11) 81.35% 8 correct out of 11 Average score= 62.69%	*Statements they should disagree/strongly disagree with:* 1) 71.43% 2) 82.86% 5) 45.72% Statements they should agree/strongly agree with: 3) 62.86% 4) 60% 6) 25.71% 7) 23.53% 8) 94.29% 9) 65.71% 10) 47.06% 11) 71.43% 7 correct out of 11 Average score= 59.145%	Statements they should disagree/strongly disagree with: 1) 78.12% 2) 78.13% 5) 37.5% Statements they should agree/strongly agree with: 3) 68.74% 4) 65.62% 6) 34.38% 7) 37.5% 8) 87.5% 9) 70.96% 10) 56.24% 11) 87.5% 8 correct out of 11 Average score= 63.835%	Statements they should disagree/strongly disagree with: 1) 67.44% 2) 83.72% 5) 32.56% Statements they should agree/strongly agree with: 3) 69.76% 4) 53.49% 6) 25.58% 7) 44.19% 8) 90.48% 9) 69.77% 10) 60.46% 11) 81.4% 8 correct out of 11 Average score= 61.71%	Statements they should disagree/strongly disagree with: 1) 72.22% 2) 77.78% 5) 38.89% Statements they should agree/strongly agree with: 3) 77.78% 4) 61.11% 6) 33.34% 7) 16.67% 8) 88.89% 9) 83.33% 10) 44.44% 11) 72.22% 7 correct out of 11 *Average score= 60.6%*	Statements they should disagree/strongly disagree with: 1) 64.1% 2) 82.05% 5) 30.77% Statements they should agree/strongly agree with: 3) 64.11% 4) 61.54% 6) 23.07% 7) 43.59% 8) 92.11% 9) 57.9% 10) 56.41% 11) 84.62% 8 correct out of 11 *Average score= 60.02%*	Statements they should disagree/strongly disagree with: 1) 77.5% 2) 82.5% 5) 37.5% Statements they should agree/strongly agree with: 3) 60% 4) 52.5% 6) 25% 7) 33.34% 8) 92.5% 9) 72.5% 10) 61.54% 11) 80% 8 correct out of 11 *Average score= 61.35%*	*Statements they should disagree/strongly disagree with:* 1) 45.45% 2) 63.63% 5) 9.09% Statements they should agree/strongly agree with: 3) 36.36% 4) 81.82% 6) 9.09% 7) 0% 8) 90.91% 9) 54.54% 10) 27.27% 11) 45.45% 4 correct out of 11 Average score= 42.146%	Statements they should disagree/strongly disagree with: 1) 62.07% 2) 79.31% 5) 48.28% Statements they should agree/strongly agree with: 3) 55.17% 4) 51.72% 6) 20.68% 7) 41.38% 8) 93.1% 9) 62.07% 10) 64.29% 11) 89.65% 8 correct out of 11 *Average score= 60.7%*	Statements they should disagree/strongly disagree with: 1) 76.67% 2) 83.33% 5) 36.67% Statements they should agree/strongly agree with: 3) 80% 4) 63.33% 6) 23.34% 7) 23.34% 8) 86.21% 9) 66.67% 10) 50% 11) 76.66% 8 correct out of 11 *Average score= 60.565%*	
17	1. Workplace organisation= 60.87% 2. Collaborative Planning= 52.17% 3. Standardised work= 52.17% 4. Problem solving= 52.17% 5. Data Analysis= 47.83% 6. Visual management= 47.83% 7. Work sequence analysis= 34.78% 8. Process mapping= 30.43% 9. None= 17.39% 10. All=8.7% 11. Other= 0%	1. Data Analysis= 47.06% 2. Visual management= 41.18% 3. Workplace organisation= 41.18% 4. Process mapping= 35.29% 5. Problem solving= 35.29% 6. Collaborative Planning= 29.41% 7. Standardised work= 29.41% 8. All= 29.41% 9. Work sequence analysis= 23.53% 10. None= 17.69% 11. Other= 11%	1. Workplace organisation= 58.14% 2. Standardised work= 58.14% 3. Problem solving= 51.16% 4. Collaborative planning= 41.86% 5. Data analysis= 39.53% 6. VM= 39.53% 7. Process mapping= 39.53% 8. Work sequence analysis= 27.91% 9. All= 11.63% 10. None= 11.63% 11. Other= 6%	1. Collaborative Planning= 50% 2. Data analysis= 50% 3. Workplace organisation= 43.33% 4. Process mapping= 40% 5. Work sequence analysis= 36.67% 6. VM= 33.33% 7. Standardised work= 33.33% 8. Problem solving= 33.33% 9. All= 26.67% 10. None= 13.33% 11. Other= 3%	1. Collaborative Planning= 61.76% 2. Data Analysis= 58.82% 3. Workplace organisation= 55.88% 4. Work sequence analysis= 52.94% 5. Visual management= 52.94% 6. Standardised work= 52.94% 7. Problem solving= 52.94% 8. Process mapping= 35.29% 9. All= 17.65% 10. Other= 11% 11. None= 5.88%	1. Workplace organisation= 57.14% 2. Standardised work= 57.14% 3. Problem solving= 46.94% 4. Collaborative Planning= 44.9% 5. Data Analysis= 42.86% 6. Process mapping= 40.82% 7. Visual management= 38.78% 8. Work sequence analysis= 30.61% 9. None= 12.24% 10. All= 10.2% 11. Other= 6%	1. Collaborative Planning= 54.24% 2. Data Analysis= 52.54% 3. Workplace organisation= 49.15% 4. Problem solving= 47.46% 5. Work sequence analysis= 45.76% 6. Visual management= 45.76% 7. Standardised work= 44.07% 8. Process mapping= 37.29% 9. All= 23.73% 10. None= 8.47% 11. Other= 8%	1. Standardised work= 55.88% 2. Workplace organisation= 52.94% 3. Problem solving= 52.94% 4. Collaborative planning= 47.06% 5. Data analysis= 47.06% 6. Visual management= 47.06% 7. Process mapping= 38.24% 8. Work sequence analysis= 35.29% 9. All= 20.59% 10. None= 11.76% 11. Other= 5%	1. Collaborative Planning= 50% 2. Standardised work= 46.88% 3. Work sequence analysis= 43.75% 4. Workplace organisation= 43.75% 5. Process mapping= 43.75% 6. Data Analysis= 37.5% 7. Problem solving= 37.5% 8. Visual management= 31.25% 9. None= 15.62% 10. All= 9.38% 11. Other= 9%	1. Data Analysis= 58.54% 2. Workplace organisation= 58.54% 3. Collaborative Planning= 51.22% 4. Problem solving= 51.22% 5. Visual management= 48.78% 6. Standardised work= 46.34% 7. Work sequence analysis= 36.59% 8. Process mapping= 36.59% 9. All= 21.95% 10. Other= 7% 11. None= 5%	1. Problem solving= 58.97% 2. Collaborative Planning= 56.41% 3. Data Analysis= 53.85% 4. Workplace organisation= 53.85% 5. Visual management= 51.28% 6. Standardised work= 51.28% 7. Process mapping= 48.72% 8. Work sequence analysis= 33.33% 9. All= 17.95% 10. None= 10.26% 11. Other= 7%	1. Workplace organisation= 43.59% 2. Collaborative Planning= 38.46% 3. Standardised work= 38.46% 4. Work sequence analysis= 35.9% 5. Data Analysis= 33.33% 6. Problem solving= 33.33% 7. Process mapping= 28.21% 8. Visual management= 25.64% 9. All= 17.95% 10. None= 12.82% 11. Other= 5%	1. Data analysis= 54.55% 2. Standardised work= 54.55% 3. Collaborative planning= 36.36% 4. Problem solving= 36.36% 5. Work sequence analysis= 27.2% 6. Visual management= 27.2% 7. Workplace organisation= 27.2% 8. All= 27.27% 9. Process mapping= 18.18% 10. None= 18.18% 11. Other= 0%	1. Workplace organisation= 55.17% 2. Collaborative Planning= 44.83% 3. Visual management= 37.93% 4. Standardised work= 37.93% 5. Problem solving= 34.48% 6. Data Analysis= 31.03% 7. Process mapping= 27.59% 8. Work sequence analysis= 24.14% 9. All= 20.69% 10. None= 6.9% 11. Other= 0%	1. Collaborative Planning= 65.52% 2. Data Analysis= 62.07% 3. Workplace organisation= 62.07% 4. Standardised work= 58.62% 5. Problem solving= 58.62% 6. Work sequence analysis= 55.17% 7. Visual management= 55.17% 8. Process mapping= 48.28% 9. All= 13.79% 10. None= 6.9% 11. Other= 6%	
18	1. CPM= 52.17% 2. Look ahead planning= 34.78% 3. Workflow PM= 30.43% 4. PCP tools= 30.43% 5. N/A= 26.09% 6. LPS= 17.39% 7. Constraint analysis= 17.39% 8. Other= 8% 9. RPS= 8%	1. CPM= 58.82% 2. Look ahead= 52.94% 3. PCP tools= 41.18% 4. LPS= 17.65% 5. N/A= 11.76% 6. Workflow PM= 11.76% 7. Constraint analysis= 11.76% 8. Other= 11% 9. RPS= 5.88%	1. CPM= 48.84% 2. Look ahead= 41.86% 3. PCP= 30.23% 4. N/A= 25.58% 5. Workflow PM= 25.58% 6. Constraint analysis= 16.28% 7. LPS= 14% 8. RPS= 7% 9. Other= 6%	1. CPM= 76.67% 2. Look ahead= 53.33% 3. PCP tools= 50% 4. Workflow PM= 30% 5. LPS= 30% 6. Constraint analysis= 30% 7. RPS= 16.67% 8. N/A= 13.33% 9. Other= 6%	1. CPM= 69.7% 2. PCP tools= 57.58% 3. Look ahead= 51.52% 4. Constraint analysis= 33.33% 5. LPS= 18.18% 6. Other= 18.18% 7. Workflow PM= 15.15% 8. N/A= 12% 9. RPS= 9%	1. CPM= 48% 2. Look ahead planning= 42% 3. PCP tools= 30% 4. N/A= 24% 5. Workflow PM= 24% 6. Constraint analysis= 18% 7. LPS= 16% 8. Other= 12% 9. RPS= 8%	1. CPM= 75.86% 2. PCP tools= 55.17% 3. Look ahead planning= 51.72% 4. Constraint analysis= 32.76% 5. Workflow PM= 22.41%% 6. LPS= 22.41% 7. RPS= 12.07% 8. N/A= 12.07% 9. Other= 10%	1. CPM= 58.82% 2. Look ahead planning= 47.06% 3. PCP tools= 38.24% 4. Workflow PM= 23.53% 5. Constraint analysis= 23.53% 6. N/A= 17.65% 7. RPS= 11.76% 8. Other= 11% 9. LPS= 8.82%	1. CPM= 64.52% 2. Look ahead planning= 41.94% 3. PCP tools= 38.71% 4. Not applicable= 19.35% 5. Workflow PM= 19.35% 6. LPS= 19.35% 7. Constraint analysis= 19.35% 8. Other= 6% 9. RPS= 3.25%	1. CPM= 66.67% 2. Look Ahead Planning= 50% 3. PCP tools= 50% 4. Constraint analysis= 33.33% 5. LPS=28.57% 6. Workflow PM= 26.19% 7. N/A= 16.67% 8. RSPS= 14%% 9. Other= 14%	1. CPM= 72.22% 2. Look ahead planning= 55.56% 3. PPC tools= 50% 4. Constraint analysis= 33.33% 5. Not Applicable= 22.22% 6. Workflow PM= 16.67% 7. LPS= 16.67% 8. RPS= 16.67% 9. Other= 0%	1. CPM= 60.53% 2. Look ahead planning= 44.74% 3. PCP tools= 34.21% 4. Constraint analysis= 26.32% 5. Not applicable= 18.42% 6. WF PM= 18.42% 7. Other= 18% 8. LPS= 15.79% 9. RPS= 7.89%	1. CPM= 64.1% 2. Look ahead Planning= 53.85% 3. PCP tools= 46.15% 4. Workflow PM= 30.77% 5. LPS=25.64% 6. Constraint analysis= 25.64% 7. N/A= 12.82% 8. RSPS= 10.26% 9. Other= 7%	1. CPM= 30% 2. Look ahead planning= 30% 3. PCP tools= 30% 4. N/A= 20% 5. Workflow PM= 20% 6. Constraint analysis= 20% 7. RPS= 10% 8. Other= 10% (said: Don't Know) 9. LPS= 0%	1. CPM= 75.86% 2. PCP tools= 48.28% 3. Look ahead planning= 41.38% 4. Constraint analysis= 31.03% 5. Workflow PM= 20.69% 6. LPS= 20.69% 7. Not applicable= 17.24% 8. RPS= 6.9% 9. Other= 3%	1. CPM= 63.33% 2. Look ahead Planning= 56.67% 3. PCP tools= 53.33% 4. LPS=30% 5. Constraint analysis= 23.33% 6. RSPS= 20% 7. Other= 13.33% 8. N/A= 13.33% 9. Workflow PM= 10%	
19	1. None= 50% 2. PDCA= 33.33% 3. Prefabrication= 20.83% 4. FRS= 12.5% 5. Other= 8%	1. None= 41.18% 2. PDCA= 41.18% 3. Prefabrication= 11.76% 4. Other= 11.76% 5. FRS= 5%	1. None= 56.82% 2. PDCA= 29.55% 3. Other= 11% 4. FRS= 9.05% 5. Prefabrication= 9.05%	1. PDCA= 46.67% 2. None= 33.33% 3. Prefabrication= 26.67% 4. Other= 13% 5. FRS= 10%	1. PDCA= 45.45% 2. None= 33.33% 3. Prefabrication= 33.33% 4. FRS= 18.18% 5. Other= 9%	1. None= 54% 2. PDCA= 30% 3. Prefabrication= 16% 4. Other= 12% 5. First Run studies= 10%	1. PDCA= 46.55% 2. None= 34.48% 3. Prefabrication strategies= 25.86% 4. First Run Studies= 13.79% 5. Other= 10%	1. None= 47.06% 2. PDCA= 41.18% 3. Prefabrication= 20.59% 4. First Run Studies= 11.76% 5. Other= 8%	1. None= 46.88% 2. PDCA= 31.25% 3. Other= 18% 4. Prefabrication= 15.62% 5. First Run Studies= 12.5%	1. PDCA= 41.46% 2. None= 39.02% 3. Prefabrication= 26.83% 4. FRS= 12.2% 5. Other= 7%	1. None= 50% 2. PDCA= 33.33% 3. Prefabrication= 33.33% 4. First Run Studies= 11.11% 5. Other= 0%	1. None= 50% 2. PDCA= 38.46% 3. Prefabrication= 12.82% 4. First Run Studies= 12.82% 5. Other= 10%	1. None= 43.95% 2. PDCA= 41.03% 3. Prefabrication= 20.51% 4. FRS= 10.26% 5. Other= 10%	1. None= 50% 2. PDCA= 30% 3. Prefabrication= 20% 4. First Run Studies= 20% 5. Other= 10% (said: Don't know)	1. None= 48.28% 2. PDCA= 41.38% 3. Prefabrication= 13.79% 4. First Run Studies= 10.34% 5. Other= 3%	1. PDCA= 46.67% 2. None= 43.33% 3. Prefabrication= 30% 4. FRS= 16.67% 5. Other= 10%	
20	1. N/A= 54.55% 2. VM= 31.82% 3. CFP= 13.84% 4. Other= 13% 5. LPS= 9.09% 6. Crane= 4.55%	1. N/A= 47% 2. VM= 35.29% 3. CFP= 17.65% 4. LPS= 17.65% 5. Crane= 0% 6. Other= 0%	1. N/A= 66.67% 2. VM= 19.05% 3. LPS= 11.9% 4. CFP= 9.52% 5. Other= 7% 6. Crane= 4.76%	1. VM= 37.93% 2. N/A= 34.48% 3. LPS= 27.59% 4. CFP= 20.69% 5. Crane= 13.79% 6. Other= 6%	1. VM= 42.42% 2. N/A= 30.3% 3. LPS= 18.18% 4. CFP= 15.15% 5. Other= 15.15% 6. Crane= 9%	1. N/A= 59.18% 2. Visual Management= 22.45% 3. LPS= 16.33% 4. CFP= 10.2% 5. Other= 8% 6. Crane= 6.12%	1. Visual Management= 40.35% 2. N/A= 33.33% 3. CFP= 19.3% 4. LPS= 19.3% 5. Crane= 10.53% 6. Other= 10%	1. Not Applicable= 47.06% 2. VM= 35.29% 3. CFP=23.53% 4. LPS= 11.56% 5. Crane= 11.56% 6. Other= 5%	1. Not Applicable= 50% 2. VM= 23.33% 3. LPS= 16.67% 4. Other= 13% 5. CFP= 10% 6. Crane= 6.67%	1. N/A= 39.02% 2. VM= 36.59% 3. LPS= 24.39% 4. CFP= 12.2% 5. Other= 9% 6. Crane= 7.32%	1. Not Applicable= 58.82% 2. VM= 23.33% 3. LPS= 17.65% 4. CFP=5.88% 5. Crane= 5.88% 6. Other= 5%	1. Not Applicable= 44.74% 2. VM= 34.21% 3. LPS= 13.16% 4. CFP= 10.53% 5. Crane= 10.53% 6. Other= 10%	1. N/A= 42.11% 2. VM= 34.21% 3. CFP= 26.32% 4. LPS= 23.68% 5. Other= 7% 6. Crane= 2.63%	1. Not Applicable= 60% 2. VM= 30% 3. Crane= 20% 4. CFP=10% 5. LPS= 10% 6. Other= 0%	1. Not Applicable= 39.39% 2. VM= 43.14% 3. CFP= 21.43% 4. LPS= 14.29% 5. Crane= 3.57% 6. Other= 3.57%	1. N/A= 50% 2. VM= 30% 3. LPS= 26.67% 4. Other= 16% 5. Crane= 10% 6. CFP= 6.67%	
21	· Yes= 26%	· Yes= 35.29%	Yes= 18.6%	Yes= 76.67%	Yes= 56.25%	Yes= 22.45%	Yes= 66.67%	· 39.39% Yes	· 61.29% Yes	· 41.46%% Yes	· 50% Yes	· 55.26% Yes	· 52.63% Yes	· 20% Yes (because one when asked to identify which, said:	· 42.86% Yes	· 40% Yes	
22	1. N/A= 39.13% 2. JIT= 26.09% 3. Don't know= 21.74% 4. VS analysis= 8.88% 5. Kanban= 8.88% 6. Other= 8.88%	1. Don't know= 53% 2. JIT= 29.41% 3. VS analysis= 11.76% 4. N/A= 5.88% 5. Kanban= 5.88% 6. Other= 5.88%	1. Don't know= 32.56% 2. N/A= 30.23% 3. JIT= 30.23% 4. VS analysis= 7% 5. Other= 2% 6. Kanban= 2%	1. Don't know= 50% 2. JIT= 26.67% 3. N/A= 16.67% 4. VS analysis= 10% 5. Other= 10% 6. Kanban= 3.33%	1. JIT= 34.28% 2. N/A= 25% 3. Don't know= 21.88% 4. Other= 15% 5. VS analysis= 12.5% 6. Kanban= 9.38%	1. Don't know= 34.69% 2. Just-In-Time= 32.65% 3. N/A= 28.57% 4. Value stream analysis= 6.12% 5. Kanban System= 2.04% 6. Other= 2.04%	1. Don't know= 33.33% 2. JIT= 28.07% 3. N/A= 22.81% 4. Other= 14% 5. VS analysis= 12.28% 6. Kanban= 7.02%	1. Don't know= 42.42% 2. JIT= 33.33% 3. N/A= 18.18% 4. Value stream analysis= 6% 5. Other= 6% 6. Kanban System= 0%	1. Don't Know= 41.94% 2. N/A= 35.48% 3. JIT= 12.9% 4. Other=12% 5. Value stream analysis= 3.23% 6. Kanban= 3.23%	1. JIT= 41.46% 2. N/A= 24.39% 3. Don't know= 19.51% 4. VS analysis= 17.07% 5. Kanban= 9.76% 6. Other= 7%	1. JIT= 38.89% 2. Not Applicable= 33. 33% 3. Don't know= 16.67% 4. Kanban System= 11.11% 5. Value stream analysis= 5.56% 6. Other= 5%	1. Don't Know= 42.11% 2. JIT= 34.21% 3. N/A= 18.42% 4. Value stream analysis= 10.

Q.	Private Individuals and Organisations	Public Organisations	Turn Over [0-100]	Turn Over [100-1000]	Turn Over [1000+]	Organisations with less than 500 employees	Organisations with more than 500 employees	0-10 Years of Experience	10-20 Years of Experience	20+ Years of Experience	NVQ and HND/HNC	Degree	Masters	Graduates and Juniors	Team leader, site manager, and project manager	Regional manager, department manager, and managerial director	Academic/Researcher
	6. Management control= 8.7% 7. Other= 0%	6. Other= 11.76% 7. Logistics= 6%	6. Production control= 4.65% 7. Other= 2%	6. Performance measurement= 20.69% 7. Other= 0%	6. Other= 12%	6. Logistics= 10.2% 7. Other= 2%	6. Performance measurement= 17.86% 7. Other= 7%	6. Logistics= 9.09% 7. Other= 6%	6. Performance measurement= 10% 7. Other= 3%	6. Logistics= 17.07% 7. Other= 4%	6. Management control= 5.56% 7. Other= 5%	6. Logistics= 10.81% 7. Other= 2%	6. Logistics= 21.05% 7. Other= 5%	6. Logistics= 10% 7. Other= 10% (said: Don't Know)	6. Logistics= 10.71% 7. Other= 0%	6. Management Control= 13.33% 7. Other= 10%	
26	· measures production planning effectiveness and workflow reliability= 18.18%	· measures production planning effectiveness and workflow reliability= 25%	· Measures production planning effectiveness and workflow reliability=14%	· measures production planning effectiveness and workflow reliability= 14.81%	· measures production planning effectiveness and workflow reliability= 18.18%	· Production planning effectiveness and workflow reliability= 16.67%%	· Production planning effectiveness and workflow reliability= 14.29%	· 15.15% (measures production planning effectiveness and workflow reliability)	· 3.33% (measures production planning effectiveness and workflow reliability)	· 25% (measures production planning effectiveness and workflow Reliability)	· 5.56% (measures production planning effectiveness and workflow reliability)	· 21.62% (effectiveness& reliability)	· 16.22 % (effectiveness& reliability)	· ZERO % (measures production planning effectiveness and workflow reliability)	· 22.22% (measures production planning effectiveness and workflow reliability)	· 23.33% (measures production planning effectiveness and workflow Reliability)	
27	1. Experience of managers= 69.57% 2. KPI= 65.22% 3. Own metrics= 21.74% 4. Process PM= 17.39% 5. International benchmarking= 13% 6. LPS= 13% 7. Balanced Scorecards= 8.7% 8. QMPMS= 8.7% 9. None= 8.7% 10. Other= 0%	1. KPI= 94.12% 2. own metrics= 58.82% 3. Experience of managers= 58.82% 4. Process PM= 29.41% 5. International benchmarking= 23.53% 6. Balanced Scorecards= 23.53% 7. LPS= 17.65% 8. QMPMS= 6% 9. None= 0% 10. Other= 0%	1. Experience of managers= 59.52% 2. KPI= 52.38% 3. Process PM= 21.43% 4. Own metrics= 19.05% 5. None= 11.9% 6. International benchmarking= 9.52% 7. Balanced scorecards= 9.52% 8. LPS= 7.14% 9. DQI= 2.38% 10. QMPMS= 2.38% 11. Other= 2%	1. KPI= 90% 2. Experience of managers= 53.33% 3. Own metrics= 36.67% 4. LPS= 30% 5. Process PM= 30% 6. Balanced scorecards= 26.67% 7. International benchmarking= 20% 8. DQI= 16.67% 9. QMPMS= 13.33% 10. Other= 6% 11. None= 0%	1. KPI= 90.91% 2. Experience of managers= 63.64% 3. Own metrics= 54.55% 4. Process PM= 33.33% 5. Balanced Scorecards= 21.21% 6. International benchmarking= 15.15% 7. LPS= 15.15% 8. QMPMS= 12.12% 9. DQI= 6.06% 10. Other= 3% 11. None= 3%	1. KPI= 57.14% 2. Experience of managers= 57.14% 3. Process PM= 24.49% 4. Our own metrics= 22.45% 5. LPS= 14.29% 6. Balanced scorecards= 10.2% 7. None= 10.2% 8. International benchmarking= 8.16% 9. DQI= 8.16% 10. QMPMS= 4% 11. Other= 4%	1. KPI= 89.66% 2. Experience of managers= 58.62% 3. Own metrics= 44.83% 4. Process PM= 29.31% 5. Balanced Scorecards= 24.14% 6. International benchmarking= 20.69% 7. LPS= 17.24% 8. QMPMS= 13.79% 9. DQI= 6.9% 10. Other= 5% 11. None= 1.72%	1. KPI= 64.71% 2. Experience of managers= 61.76% 3. Process performance measures= 29.41% 4. Own metrics= 26.47% 5. International benchmarking= 17.65% 6. Balanced Score cards= 11.76% 7. LPS= 8.82% 8. DQI= 8.82% 9. QMPMS= 5.88% 10. None= 5.88% 11. Other= 5%	1. KPI= 77.42% 2. Experience of managers= 51.61% 3. Own metrics= 25.81% 4. Process Performance measures= 19.35% 5. Balanced score cards= 16.13% 6. LPS= 12.9% 7. International benchmarking= 9.68% 8. None= 9.68% 9. QMPMS= 6.45% 10. DQI= 3% 11. Other= 3%	1. KPI= 80.49% 2. Experience of managers= 58.54% 3. Own metrics= 48. 78% 4. Process PM= 31.71%% 5. LPS= 24.39% 6. Balanced Scorecards= 24.39% 7. International benchmarking= 17.07% 8. QMPMS= 14.63% 9. DQI= 9.76% 10. Other= 4% 11. None= 2.44%	1. KPI= 88.24% 2. Experience of managers= 47.06% 3. Own metrics= 29.41% 4. International benchmarking= 23.53% 5. Process performance measures= 23.53% 6. LPS= 11.76% 7. Balanced Score cards= 11.76% 8. DQI= 5.88% 9. QMPMS= 5.88% 10. Other= 5.88% 11. None= 0%	1. KPI= 71.05% 2. Experience of managers= 71.05% 3. Own metrics= 50% 4. Process Performance measures= 28.95% 5. LPS= 18.42% 6. Balanced score cards= 13.16% 7. QMPMS= 10.53% 8. International benchmarking= 7.89% 9. DQI= 7.89% 10. None= 7.89% 11. Other= 2%	1. KPI= 71.79% 2. Experience of managers= 51.28% 3. Process PM= 30.77% 4. Balanced Scorecards= 23.08% 5. Own metrics= 20.51% 6. LPS= 17.95% 7. International benchmarking= 15.38% 8. QMPMS= 10.26% 9. DQI= 5.135 10. None= 5.13% 11. Other= 2%	1. Experience of managers= 70% 2. KPI= 30% 3. International benchmark= 20% 4. None= 20% 5. DQI= 10% 6. QMPMS= 10% 7. Own metrics= 10% 8. Process PM= 10% 9. Other= 10% (said: Customer feedback) 10. Balanced Score cards= 0% 11. LPS= 0%	1. KPI= 82.76% 2. Experience of managers= 51.61% 3. Process PM= 34.48% 4. Own metrics= 31.03% 5. Balanced score cards= 24.14% 6. LPS= 20.69% 7. International benchmarking= 10.34% 8. None= 6.9% 9. QMPMS= 6.9% 10. DQI= 0% 11. Other= 3%	1. KPI= 75.86% 2. Experience of managers= 68.96% 3. Own metrics= 55.17% 4. Process PM= 31.03%% 5. LPS= 24.14% 6. Balanced Scorecards= 20.69% 7. International benchmarking= 13.79% 8. DQI= 10.34% 9. QMPMS= 6.9% 10. Other= 0% 11. None= 0%	
28	*Mean score for 'non-financial' performance indicators (Only those achieving a score of 8 and above will be considered)* 1. Safety= 9.521 2. Customer Satisfaction= 9.174 3. Quality= 8.869 4. Functionality= 7.608 5. Planning Efficiency= 7.562 6. Productivity= 7.521 7. Team performance= 7.434	*Mean score for 'non-financial' performance indicators (Only those achieving a score of 8 and above will be considered)* 1. Safety= 9.625 2. Customer Satisfaction= 9.25 3. Quality= 8.875 4. Functionality= 8.0 5. Productivity= 8.0 6.Team performance= 7.9375 7. Planning Efficiency= 7.5625	*Mean score for 'non-financial' performance indicators (Only those achieving a score of 8 and above will be considered)* 1. Safety= 9.325 2. Customer Satisfaction= 9.14 3. Quality= 8.813 4.Functionality= 7.928 5. Productivity= 7.907 6. Team performance= 7.674 7. Planning Efficiency= 7.604	*Mean score for 'non-financial' performance indicators (Only those achieving a score of 8 and above will be considered)* 1. Safety= 9.714 2. Customer Satisfaction= 8.93 3. Quality= 8.75 4. Functionality= 7.965 5. Productivity= 7.931 6. Team performance= 7.931 7. Planning Efficiency= 7.482	*Mean score for 'non-financial' performance indicators (Only those achieving a score of 8 and above will be considered)* 1. Safety= 9.545 2. Customer Satisfaction= 9.454 3. Quality= 8.67 4. Planning Efficiency= 7.757 5. Team performance= 7.727 6. Productivity= 7.515 7. Functionality= 7.272	*Mean score for 'non-financial' performance indicators (Only those achieving a score of 8 and above will be considered)* 1. Safety= 9.346 2. Customer Satisfaction= 8.918 3. Quality= 8.734 4. Functionality= 7.6875 5. Team performance= 7.612 6. Productivity= 7.591 7. Planning Efficiency= 7.408	*Mean score for 'non-financial' performance indicators (Only those achieving a score of 8 and above will be considered)* 1. Safety= 9.637 2. Customer Satisfaction= 9.344 3. Quality= 8.793 4. Team performance= 7.965 5. Productivity= 7.965 6. Planning Efficiency= 7.775 7. Functionality= 7.741	*Mean score for 'non-financial' performance indicators (Only those achieving a score of 8 and above will be considered)* 1. Safety= 9.47 2. Customer Satisfaction= 9.11 3. Quality= 8.941 4. Functionality= 8.242 5. Productivity= 8.117 6. Team performance= 7.882 7. Planning Efficiency= 7.823	*Mean score for 'non-financial' performance indicators (Only those achieving a score of 8 and above will be considered)* 1. Safety= 9.129 2. Customer Satisfaction= 9.193 3. Quality= 8.451 4. Productivity= 8.064 5. Functionality= 8.032 6. Team performance= 8.032 7. Planning Efficiency= 7.806	*Mean score for 'non-financial' performance indicators (Only those achieving a score of 8 and above will be considered)* 1. Safety= 9.804 2. Customer Satisfaction= 9.195 3. Quality= 8.902 4. Team performance= 7.609 5. Productivity= 7.365 6. Planning Efficiency= 7.317 7. Functionality= 7.048	*Mean score for 'non-financial' performance indicators (Only those achieving a score of 8 and above will be considered)* 1. Safety= 9.89 2. Customer Satisfaction= 9.556 3. Quality= 9.278 4. Planning Efficiency= 8.556 5. Team performance= 8.44 6. Productivity= 8.05 7. Functionality= 7.778	*Mean score for 'non-financial' performance indicators (Only those achieving a score of 8 and above will be considered)* 1. Safety= 9.756 2. Customer Satisfaction= 9.189 3. Quality= 8.837 4. Functionality= 7.81 5. Productivity= 7.783 6. Team performance= 7.54 7. Planning Efficiency= 7.081	*Mean score for 'non-financial' performance indicators (Only those achieving a score of 8 and above will be considered)* 1. Safety= 9.589 2. Customer Satisfaction= 8.97 3. Quality= 8.717 4.Planning Efficiency= 7.897 5. Functionality= 7.842 6. Productivity= 7.794 7. Team performance= 7.717	*Mean score for 'non-financial' performance indicators (Only those achieving a score of 8 and above will be considered)* 1. Safety= 9.0 2. Quality= 8.7 3. Customer Satisfaction= 8.4 4. Functionality= 7.8 5. Productivity= 7.5 6. Planning Efficiency= 7.5 7. Team performance= 7.1	*Mean score for 'non-financial' performance indicators (Only those achieving a score of 8 and above will be considered)* 1. Safety= 9.75 2. Customer Satisfaction= 9.142 3. Quality= 8.857 4. Functionality= 7.75 5. Team performance= 7.642 6. Productivity= 7.642 7. Planning Efficiency= 7.357	*Mean score for 'non-financial' performance indicators (Only those achieving a score of 8 and above will be considered)* 1. Safety= 9.8 2. Customer Satisfaction= 9.4 3. Quality= 8.67 4. Team performance= 7.7 5. Productivity= 7.6 6. Planning Efficiency= 7.43 7. Functionality= 7.413	
29	1. less waste= 81.82% 2. improved productivity= 72.73% 3. fewer defects and improved quality= 72.73% 4. more client satisfaction 68.18% 5. reduced cost= 68.18%	1. Less waste= 88.24% 2. Improved productivity= 76.47% 3. fewer defects and improved quality= 70.59% 4. reduced cost= 70.59% 5. more client satisfaction= 58.82%	1. Less waste= 75% 2. improved productivity= 67.5% 3. fewer defects and improved quality= 62.5% 4. Reduced cost= 60% 5. more client satisfaction= 57.5%	1. improved productivity= 86.67% 2. Less waste= 83.33% 3. Reduced cost= 76.67% 4. fewer defects and improved quality= 73.33% 5. more client satisfaction= 63.33%	1. Less waste= 69.7% 2. fewer defects and improved quality= 69.7% 3. improved safety and health 4. conditions= 57.58% 5. improved productivity= 57.58% 6. reduced cost= 51.52%	1. less waste= 76.6% 2. improved productivity= 74.47% 3. fewer defects and improved quality= 65.96% 4. reduced cost= 59.57% 5. more client satisfaction= 57.45%	1. less waste= 74.14% 2. fewer defects and improved quality= 68.97% 3. improved productivity= 67.24% 4. reduced cost= 63.79% 5. more client satisfaction and improved safety and health conditions= 55.17%	1. less waste= 83.87% 2. Improved productivity=74.19% 3. Reduced cost= 74.19% 4. fewer defects and improved quality= 64.52% 5. increased profit/turnover AND more client satisfaction 51.61%	1. Less waste= 74.19% 2. Improved productivity= 64.52% 3. Fewer defects and improved quality= 64.52% 4. More client satisfaction= 54.84% 5. improved safety and health conditions= 51.61%	1. Improved productivity= 71.43% 2. Fewer defects and improved quality= 71.43% 3. Less waste= 69.05% 4. Reduced cost= 64.29% 5. More client satisfaction= 59.52%	1. Improved productivity=70.59% 2. fewer defects and improved quality = 70.59% 3. less waste= 64.71% 4. increased profit= 64.71% 5. improved safety and health conditions= 64.71%	1. Less waste= 73.68% 2. Improved productivity= 68.42% 3. Fewer defects and improved quality= 65.79% 4. Reduced cost= 55.26% 5. More client satisfaction= 47.37%	1. Less waste= 81.08% 2. Improved productivity= 70.27% 3. Fewer defects and improved quality= 70.27%, 4. Reduced cost= 70.27% 5. More client satisfaction= 64.86%	1. less waste= 88.89% 2. Improved productivity=66.67% 3. Reduced cost= 66.67% 4. fewer defects and improved quality= 55.56% 5. increased profit/turnover= 44.44%	1. Less waste= 72.41% 2. Improved productivity= 65.52% 3. Fewer defects and improved quality= 62.07% 4. Reduced cost= 55.17% 5. More client satisfaction= 51.72%	1. Fewer defects and improved quality= 82.76% 2. Improved productivity= 72.41 3. More client satisfaction= 72.41% 4. Increased Predictability= 72.41% 5. Less waste, Reduced cost, and increased profit= 65.52%	
30	1. Risk management and mitigation= 60.87% 2. Cost and Value Management= 60.87% 3. LC= 26% 4. SC assistance= 26% 5. All= 26% 6. Other= 0%	1. Risk management= 62.5% 2. Cost and Value Management= 43.75% 3. All= 25% 4. LC= 18.75% 5. SC assistance= 12.5% 6. Other= 12%	1. Cost and Value Management= 61% 2. Risk management= 53.66% 3. LC= 22% 4. SC assistance= 22% 5. All= 22% 6. Other= 9%	1. Risk management= 62% 2. Cost and Value management= 58.62% 3. SC assistance= 38% 4. All= 31% 5. LC= 13.79% 6. Other= 3%	1. Risk management= 48.48% 2. Cost and Value management= 48.48% 3. All= 27.27% 4. LC= 15.15% 5. SC assistance= 15.15% 6. Other= 3%	1. Cost and Value Management= 59.57% 2. Risk management= 57.45% 3. All= 21.28% 4. LC= 19.15% 5. SC assistance= 19.15% 6. Other= 10%	1. Cost and Value Management= 51.72% 2. Risk management= 51.72% 3. All= 29.31% 4. SC assistance= 27.59% 5. LC= 15.52% 6. Other= 3%	1. Cost and Value Management= 66.67% 2. Risk Management= 54.55% 3. LC= 21.21% 4. All= 18.18% 5. SC assistance= 15.15% 6. Other= 9%	1. Cost and Value Management= 48.39% 2. Risk Management= 45.16% 3. All= 32.26% 4. SC assistance= 32.26% 5. LC= 12.9% 6. Other= 6%	1. Risk Management= 60% 2. Cost and Value Management= 52.5% 3. All= 27.5% 4. SC assistance= 25% 5. LC= 17.5% 6. Other= 5%	1. Risk Management= 62.5% 2. Cost and Value Management= 43.75% 3. All= 37.5% 4. SC assistance= 31.25% 5. LC= 18.75% 6. Other= 6%	1. Risk Management= 64.86%% 2. Cost and Value Management= 45.95%% 3. All= 27.03% 4. SC assistance= 27.03% 5. LC= 18.92% 6. Other= 8%	1. Cost and Value Management= 66.67% 2. Risk Management= 46.15% 3. SC assistance= 23.08% 4. All= 20.51% 5. LC= 15.38% 6. Other= 5%	1. Risk Management= 50% 2. Cost and Value Management= 50% 3. All= 20% 4. LC= 10% 5. Other= 10% (said: Don't know) 6. SC assistance= 0%	1. Cost and Value Management= 60.71% 2. Risk Management= 39.29% 3. All= 28.57% 4. SC assistance= 17.86% 5. LC= 3.57% 6. Other= 0%	1. Risk Management= 65.52% 2. Cost and Value Management= 51.72% 3. SC assistance= 34.48% 4. All= 31.03% 5. LC= 31.03 6. Other= 5%	
31	1. N/A= 31.82% 2. International standards= 31.82% 3. BREAM= 18.18% 4. SC assistance= 13.64% 5. LC= 13.64% 6. Other= 13% 7. All= 4.55%	1. International standards= 58.82% 2. BREAM= 47% 3. SC assistance= 17.65% 4. LC= 11.76% 5. Other= 11% 6. All= 5.88% 7. N/A= 0%	1. BREAM= 31.71% 2. International standards= 29.27% 3. N/A= 26.83% 4. LC= 14.63% 5. Other= 12% 6. All= 7.32% 7. SC assistance= 7.32%	1. International standards= 70% 2. BREAM= 46.67% 3. SC assistance= 36.67% 4. LC= 16.67% 5. N/A= 10% 6. All= 10% 7. Other= 3%	1. International standards= 56.25% 2. BREAM= 40.62% 3. SC assistance= 25% 4. All= 15.62% 5. Other= 6% 6. N/A= 6% 7. LC= 6.25%	1. BREAM= 37.5% 2. International standards= 31.25% 3. N/A= 25% 4. LC= 18.75% 5. Other= 10% 6. SC assistance= 4.17% 7. All= 4.17%	1. International standards= 64.91% 2. BREAM= 40.35% 3. Supply Chain Assistance= 35.09% 4. All=15.79% 5. LC= 8.77% 6. N/A= 7% 7. Other= 5%	1. International standards= 45.16% 2. BREAM= 35.48% 3. All= 12.9% 4. N/A= 12.9% 5. SC assistance= 9.68% 6. LC= 9.68% 7. Other= 6%	1. International standards= 61.29% 2. BREAM= 48.39% 3. SC assistance= 25.81% 4. N/A= 16.13% 5. LC= 9.68% 6. All= 9.68% 7. Other= 3%	1. International standards= 45.24% 2. BREAM= 35.71% 3. SC assistance= 26.19% 4. LC= 19.05% 5. N/A= 14.29% 6. All= 9.52% 7. Other= 11%	1. International standards= 62.5% 2. SC assistance= 43.75% 3. BREAM= 37.5% 4. LC= 18.75% 5. N/A= 12.5% 6. All=6.25% 7. Other= 0%	1. International standards= 47.37% 2. BREAM= 39.47% 3. SC assistance= 23.68% 4. N/A= 13.16% 5. LC= 13.16% 6. All= 10.53% 7. Other= 7%	1. International standards= 46.15% 2. BREAM= 35.9% 3. N/A= 15.38% 4. LC= 12.82% 5. All= 10.26% 6. SC assistance= 10.26% 7. Other= 10%	1. BREAM= 33.33% 2. All= 22.22% 3. N/A= 22.22% 4. SC assistance= 11.11% 5. LC= 11.11% 6. Other= 11 % (said: Don't Know) 7. International standards= 0%	1. International standards= 65.52% 2. BREAM= 44.83% 3. SC assistance= 24.14% 4. N/A= 10.34% 5. All= 6.9% 6. LC= 3.45% 7. Other= 3%	1. International standards= 48.28% 2. BREAM= 27.59% 3. LC= 20.69% 4. N/A= 17.24% 5. SC assistance= 17.24% 6. Other= 13% 7. All= 6.7%	
32	1. Community engagement= 47.83% 2. In-house training= 34.78% 3. Job knowledge and Skills scheme= 34.78% 4. Safety programmes= 30.43% 5. N/A= 21.74% 6. Lean culture= 21.74% 7. Team development= 21.74% 8. All= 4.35% 9. Other= 4%	1. In-house training= 41.18% 2. Safety programmes= 41.18% 3. Community engagement= 41.18% 4. Job knowledge and skills scheme= 35.29% 5. Team development= 29.41% 6. Other= 17% 7. Lean culture= 11.76% 8. Other= 17% 9. All= 11.76%	1. In-house training= 35.71% 2. Job knowledge and Skills scheme= 33.33% 3. Team development= 28.57% 4. Community engagement= 26.19% 5. N/A= 16.67% 6. Lean culture= 14.29% 7. Safety programmes= 14.29% 8. Other= 11% 9. All= 4.76%	1. In-house training= 60% 2. Community engagement 56.67% 3. Safety programmes= 50% 4. Job knowledge and Skills scheme= 43.33% 5. Team development= 33.33% 6. Lean culture= 20% 7. All= 10% 8. N/A= 6.67% 9. Other= 3%	1. In-house training= 54.55% 2. Community engagement= 45.45% 3. Safety programmes= 33.33% 4. Job knowledge and Skills scheme= 24.24% 5. All=21.21% 6. Team development= 18.18% 7. Lean culture= 15.15% 8. Other= 12% 9. N/A= 3%	1. In-house training= 36.73% 2. Job knowledge and Skills scheme= 28.57% 3. Team development Programme= 28.57% 4. Community engagement= 28.57% 5. N/A= 18.37% 6. Safety programmes= 18.37% 7. Lean culture= 12.24% 8. Other= 12.24% 9. All= 6%	1. In-house training= 58.62% 2. Community engagement= 51.72% 3. Safety programmes= 41.38% 4. Job knowledge and skills scheme= 37.93% 5. Team development= 25.86% 6. Lean culture= 20.69% 7. All= 17.24% 8. Other= 8% 9. N/A= 1.72%	1. In-house training= 51.52% 2. Job knowledge and skills scheme= 39.39% 3. Community engagement= 33.33% 4. Team development= 24.24% 5. Safety programmes= 24.24% 6. Creating a Lean culture= 18.18% 7. All=12.12% 8. Other= 6%	1. In-house training= 51.61% 2. Community engagement= 48.39% 3. Safety programmes= 35.48% 4. Team development= 29.03% 5. Job knowledge and Skills scheme= 29.03% 6. All= 12.9% 7. Creating a Lean culture= 9.68% 8. Other= 6%	1. In-house training= 45.24% 2. Community engagement= 40.48% 3. Safety programmes= 33.33% 4. Job knowledge and Skills scheme= 33.33% 5. Team development= 28.57% 6. Lean culture= 21.43% 7. Other=16% 8. All= 11.9%	1. In-house training= 64.71% 2. Job knowledge and skills scheme= 58.82% 3. Team development= 35.29% 4. Community engagement= 35.29% 5. Creating a Lean culture= 29.41% 6. Safety programmes= 29.41% 7. All=11.76% 8. Other= 5%	1. In-house training= 47.37% 2. Community engagement= 39.47% 3. Team development= 34. 2% 4. Job knowledge and Skills scheme= 31.58% 5. Safety programmes= 28.95% 6. Creating a Lean culture= 15.79% 7. All= 15.79% 8. Other= 15%	1. Community engagement= 48.72% 2. In-house training= 41.03% 3. Safety programmes= 33.33% 4. Job knowledge and Skills scheme= 25.64% 5. Team development= 23.08% 6. Lean culture= 12.82% 7. All= 10.26% 8. Other= 5%	1. In-house training= 30% 2. N/A= 20% 3. Creating a Lean culture= 20% 4. All= 20% 5. Job knowledge and skills scheme= 10% 6. Community engagement= 10% 7. Team development= 10% 8. Safety programmes= 10% 9. Other= 10% (said: Not sure what you mean)	1. In-house training= 58.62% 2. Safety programmes= 44.83 3. Community engagement= 41.38% 4. Job knowledge and Skills scheme= 37.93% 5. Team development= 31.03% 6. All= 10.34% 7. Creating a Lean culture= 10.34% 8. Other= 0%	1. In-house training= 46.67% 2. Community engagement= 43.33% 3. Job knowledge and Skills scheme= 26.67% 4. Team development= 26.67% 5. Safety programmes= 26.67% 6. Lean culture= 20% 7. Other=13% 8. All= 10%	
33	1. To improve the quality of our outputs= 59% 2. To improve our rate of client Satisfaction= 59% 3. To increase our profit= 54.55% 4. To keep up-to-date= 31.82% 5. As a respond to the Egan's report= 27.27% 6. When a major problem Occurs= 13.64% 7. Other= 4% 8. We are satisfied, no need to change= 4%	1. To improve our rate of client satisfaction= 52.94% 2. To improve the quality of our outputs= 47% 3. To increase our profit= 17% 4. To keep up-to-date= 29.41% 5. Other= 17% 6. As a respond to the Egan's report= 5.88% 7. We are satisfied, no need to change= 5.88% 8. When a major problem Occurs= 0%	1. To improve our rate of client satisfaction= 53.85% 2. To increase our profit= 54% 3. To improve the quality of our outputs= 46.15% 4. To keep up-to-date= 28.21% 5. As a respond to the Egan's report= 15.38% 6. We are satisfied, no need to change= 12.82% 7. Other= 12% 8. When a major problem occurs= 10.26%	1. To improve the quality of our Outputs= 63.33% 2. To increase our profit= 60% 3. To improve our rate of client satisfaction= 56.67% 4. To keep up-to-date= 36.67% 5. As a respond to the Egan's report= 23.33% 6. When a major problem occurs= 10% 7. We are satisfied, no need to change= 3.33% 8. Other= 3.33%	1. To improve our rate of client satisfaction= 51.52% 2. To increase our profit= 45.5% 3. To improve the quality of our outputs= 42.42% 4. To keep up-to-date= 39.39% 5. Other= 27% 6. As a respond to the Egan's report= 12.12% 7. We are satisfied, no need to change= 9% 8. When a major problem occurs= 9%	1. To improve our rate of client Satisfaction= 48.89% 2. To increase our profit and /or Turnover= 48.89% 3. To improve the quality of our Outputs= 46.67% 4. To keep up-to-date= 26.67% 5. As a respond to the Egan's report= 15.56% 6. Other= 13% 7. We are satisfied, no need to change= 11.11% 8. When a major problem Occurs= 11.11%	1. To improve our rate of client Satisfaction= 58.62% 2. To increase our profit and /or Turnover= 55.17% 3. To improve the quality of our Outputs= 51.72% 4. To keep up to date= 41.38% 5. As a respond to the Egan's report= 17.24% 6. Other= 15% 7. When a major problem Occurs= 8.62% 8. We are satisfied; No need to change= 6.9%	1. To increase our profit and /or turnover= 56.25% 2. To improve the quality of our outputs= 52.12% 3. To improve our rate of client satisfaction= 53.12% 4. To keep up-to-date = 37.5% 5. Other= 18% 6. When a major problem occurs= 15.62% 7. We are satisfied, no need to change= 5.38% 8. As a respond to the Egan's report= 5.38%	1. To improve our rate of client satisfaction= 58.06% 2. To increase our profit and /or turnover= 45.16% 3. To improve the quality of our outputs= 38.71% 4. To keep up to date= 29.03% 5. As a respond to Egan's report= 16.13% 6. Other= 16.13% 7. We are satisfied= 9.68% 8. When a major problem occurs= 3.23%	1. To improve the quality of our Outputs= 53.86% 2. To increase our profit and /or turnover= 53.86% 3. To improve our rate of client satisfaction= 51.28% 4. To improve the quality of our outputs= 37.5% 5. As a respond to the Egan's report= 25% 6. When a major problem occurs/occurred=12.5% 7. Other= 12% 8. We are satisfied, No need to change= 7.69%	1. To improve our rate of client satisfaction= 62.5% 2. To keep up-to-date with any new emerging management concepts= 50% 3. To increase our profit and /or turnover= 50% 4. To improve the quality of our outputs= 37.5% 5. As a respond to the Egan's report= 25% 6. When a major problem occurs/occurred=12.5% 7. Other= 12% 8. We are satisfied, no need to change= 0%	1. To improve the quality of our outputs= 55.26% 2. To improve our rate of client satisfaction= 55.26% 3. To increase our profit and /or turnover= 52.63% 4. To keep up to date= 28.95% 5. We are satisfied= 13.16% 6. Other= 13% 7. As a respond to Egan's report= 10.53% 8. When a major problem occurs= 5.26%	1. To increase our profit and /or turnover= 54.05% 2. To improve our rate of client satisfaction= 48.65% 3. To improve the quality of our outputs= 48.65% 4. To keep up-to-date= 32.43% 5. As a respond to Egan's report= 21.62% 6. Other= 13% 7. When a major problem occurs= 10.81% 8. We are satisfied, No need to change= 8.11%	1. To increase our profit and /or turnover= 55.56% 2. To improve our rate of client satisfaction= 44.44% 3. To improve the quality of our outputs= 33.33% 4. To keep up-to-date = 37.5% 5. When a major problem occurs= 22.22% 6. Other= 22% (they said: Don't know and N/A) 7. We are satisfied, no need to change= 11.11% 8. As a respond to the Egan's report= 0%	1. To improve the quality of our outputs= 48.28% 2. To improve our rate of client satisfaction= 48.28% 3. To increase our profit and /or turnover= 48.28% 4. To keep up to date= 44.83% 5. As a respond to Egan's report= 24.14% 6. We are satisfied= 10.34% 7. When a major problem occurs= 6.9% 8. Other= 0%	1. To improve our rate of client satisfaction= 65.52% 2. To improve the quality of our Outputs= 62.07% 3. To increase our profit and /or turnover= 51.72% 4. To keep up-to-date= 37.93% 5. As a respond to Egan's report= 20.69% 6. Other= 10% 7. When a major problem occurs= 3.45% 8. We are satisfied, No need to change= 3.45%	
34	*Only barriers with a mean score of 4.0 and above will be classified as significant barriers :* Lack of adequate Lean awareness = 4.6 Lack of top management commitment= 4.44 Cultural issues= 4.08 Fragmentation & subcontracting= 3.96 Procurement & contracts= 3.96 Time & commercial pressure= 3.96 Educational issues=3.88 Lack of process based PMS= 3.8 Financial issues= 3.56 Design/Construction Dichotomy= 3.5	*Only barriers with a mean score of 4.0 and above will be classified as significant barriers:* Lack of adequate Lean awareness= 4.294 Cultural issues= 4.235 Fragmentation & subcontracting= 4.235 Lack of top management commitment= 3.824 Procurement & contracts= 3.588 Lack of process based PMS= 3.588 Time & commercial pressure= 3.529 Educational issues= 3.294 Financial issues= 3.118 Design/Construction Dichotomy= 2.941	*Only barriers with a mean score of 4.0 and above will be classified as significant barriers :* Lack of adequate Lean awareness = 4.256 Lack of top management commitment= 4.163 Fragmentation & subcontracting= 3.977 Cultural issues= 3.953 Time & commercial pressure= 3.907 Educational issues= 3.767 Procurement & contracts= 3.744 Lack of process based PMS= 3.721 Financial issues= 3.581 Design/Construction Dichotomy= 3.476	*Only barriers with a mean score of 4.0 and above will be classified as significant barriers :* Lack of adequate Lean awareness= 4.469 Cultural issues= 4.031 Lack of top management commitment= 3.938 Time & commercial pressure= 3.806 Fragmentation & subcontracting= 3.719 Procurement & contracts= 3.594 Educational issues= 3.594 Design/Construction Dichotomy= 3.484 Lack of process based PMS= 3.469 Financial issues= 3.188	*Only barriers with a mean score of 4.0 and above will be classified as significant barriers :* Lack of adequate Lean awareness = 4.212 Cultural issues= 4.152 Lack of top management commitment= 4.030 Time & commercial pressure= 3.879 Procurement & contracts= 3.844 Fragmentation & subcontracting= 3.688 Financial issues= 3.576 Lack of process based PMS= 3.469 Educational issues= 3.438 Design/Construction Dichotomy= 3.313	*Only barriers with a mean score of 4.0 and above will be classified as significant barriers:* Lack of adequate Lean awareness = 4.275 Lack of top management commitment= 4.137 Cultural issues= 3.9619 Fragmentation & subcontracting= 3.961 Time & commercial pressure= 3.882 Procur

4.3.3 Soft aspects of lean: Questions 10-17

Lean is a philosophy. Without the philosophy tools are not nearly as effective. This requires creating a lean culture & developing collaborative relationships within organisations. In this set of questions, there are twelve areas that have been identified by the author as the „soft aspects of lean", or fundamental tools that could enable organisations to consider their readiness for and progress along the lean journey. These twelve areas are namely: lean awareness and understanding, the ability to motivate others, lean commitment, lean capability building, work sequence analysis, data analysis, visual management, workplace-organisation, standardising work, process mapping, and problem solving, and developing collaborative relationships and partnerships. Questions 10, 15, 16, and 17 have been created by the author, while questions 11-14 have been adopted and modified from Terry and Smith (2011). In each of these questions (11-14), participants had to choose only one statement out of five. The results will be analysed as shown in Table 4.2.

Table 4.2: Measurement scale for questions 11-14, based on median values adopted from Terry & Smith (2011)

Statement 1	Statement 2	Statement 3	Statement 4	Statement 5
Traditional	Learning	Leading	World class	Currently invincible

Question 10

Table 4.3: Awareness of the LCI-UK (Author)

10. Have you heard of the Lean Construction Institute in the UK (LCI-UK)?

	Responses	Percent
Yes:	75	65.79%
No:	39	34.21%
Total Responded to this question:	114	81.43%
Total who skipped this question:	26	18.57%
Total:	140	100%

This question was included to measure the participant‟s awareness of the LCI-UK. As can be seen from Table 4.3 above, almost 66% of all the respondents were aware of the LCI-UK, while about 34% were not aware.

Question 11

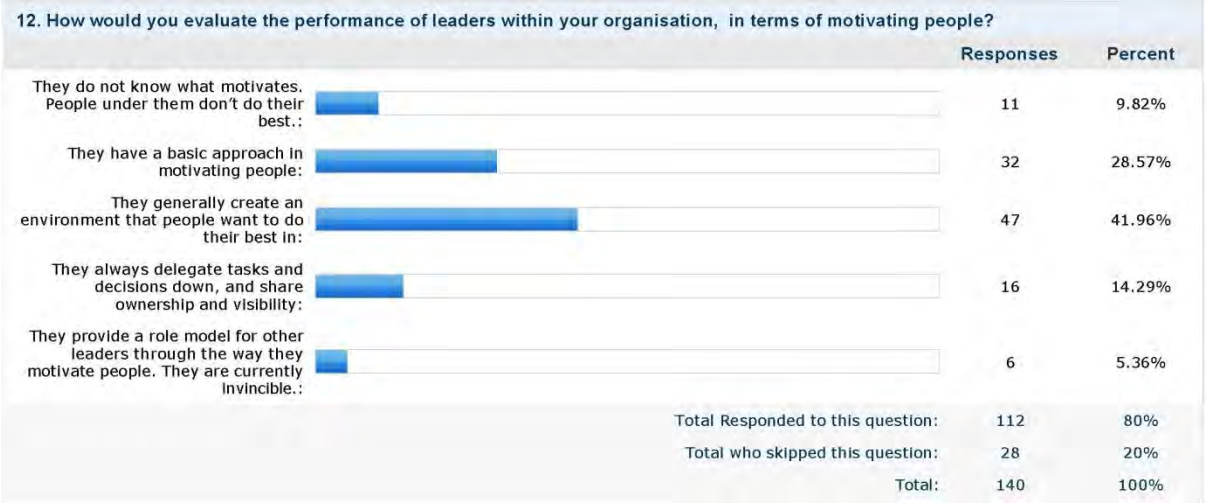
Table 4.4: The level of lean capability building within construction organisations (Author)

This question was used to measure the level of lean capability building within construction organisations. As can be seen in Table 4.4 , more than half (nearly 54%) of the respondents acknowledged that there have not been any attempts to provide formal lean training within their organisations; and that any resident lean knowledge is only through chance and personal interest. All other responses are shown in Table 4.4. By referring to the median value, the results indicate that the overall level of lean capability building of the organisations involved in the study is classified as „Traditional“ (Table 4.5 below).

Table 4.5: Classifying the organisations' level of lean capability building (Author)		
Statistical Approach	**Value (Statement number)**	**Classification**
Mode Analysis	1	Traditional
Median Analysis	1	Traditional

Question 12

Table 4.6: Evaluating the performance of leaders within construction organisations, in terms of their ability to motivate people (Author)

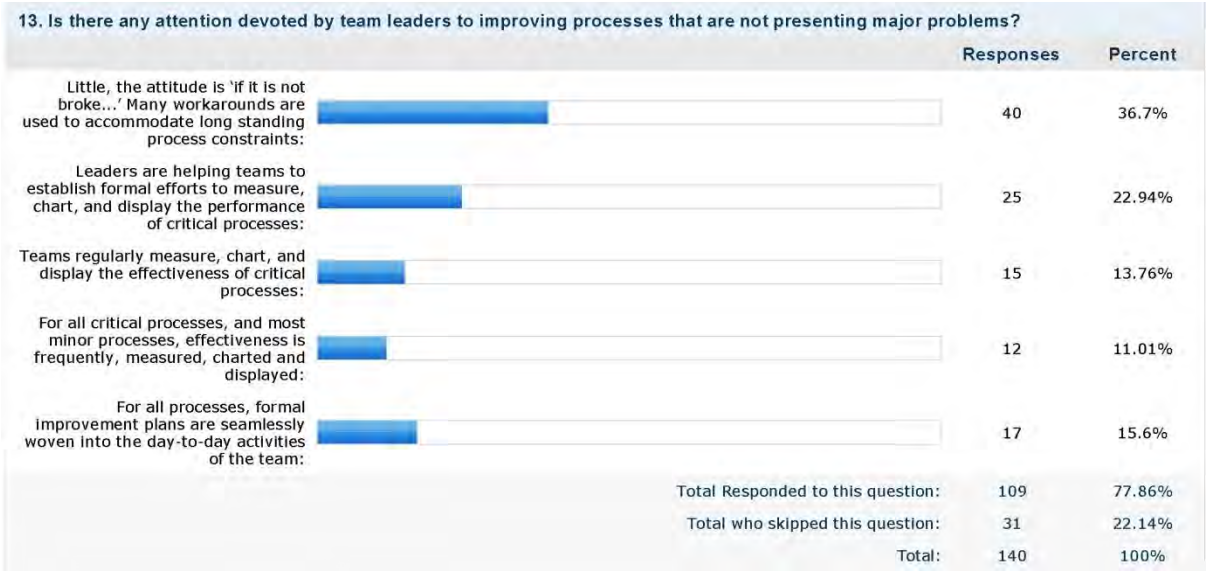


This question was used to evaluate the performance of leaders within organisations, in terms of their ability to motivate others. As can be seen from Table 4.6, the highest proportion of responses was for statement 3. Also, the median values indicated the same result (Table 4.7). This illustrates that the leaders within the organisations involved in this study, generally create an environment that people want to do their best in.

Table 4.7: Classifying the performance of leaders within construction organisations, in terms of their ability to motivate others (Author)		
Statistical Approach	**Score (Statement number)**	**Classification**
Mode Analysis	3	Leaders
Median Analysis	3	Leaders

Question 13

Table 4.8: The level of lean commitment within construction organisations (Author)

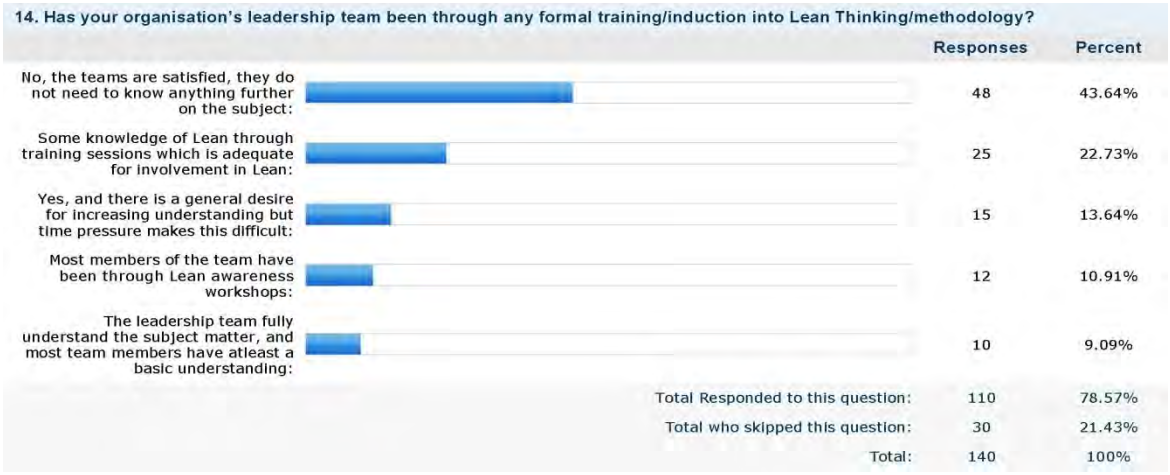


This question was used to evaluate one of the most important soft aspects of lean which is „lean commitment". Hence, the author considered this question to be very critical; a special option was used to randomise the order of the given statements. This means that for participants, the five statements mentioned above (Table 4.8) appeared to them in different/random orders. This approach was adopted by the author to make sure that participants will make precise selections, and will not just follow the measurement scale, or be neutral.

The results from Table 4.8 show that the highest proportion of the respondents selected statements 1 and 2 respectively. Interestingly, statement 5 came third. As a result, the median score for this question illustrates that the level of lean commitment of leaders within organisations, involved in this study, is classified as „Learning".

Question 14

Table 4.9: Level of lean awareness and understanding of leadership teams within construction organisations, obtained through formal training/induction (Author)



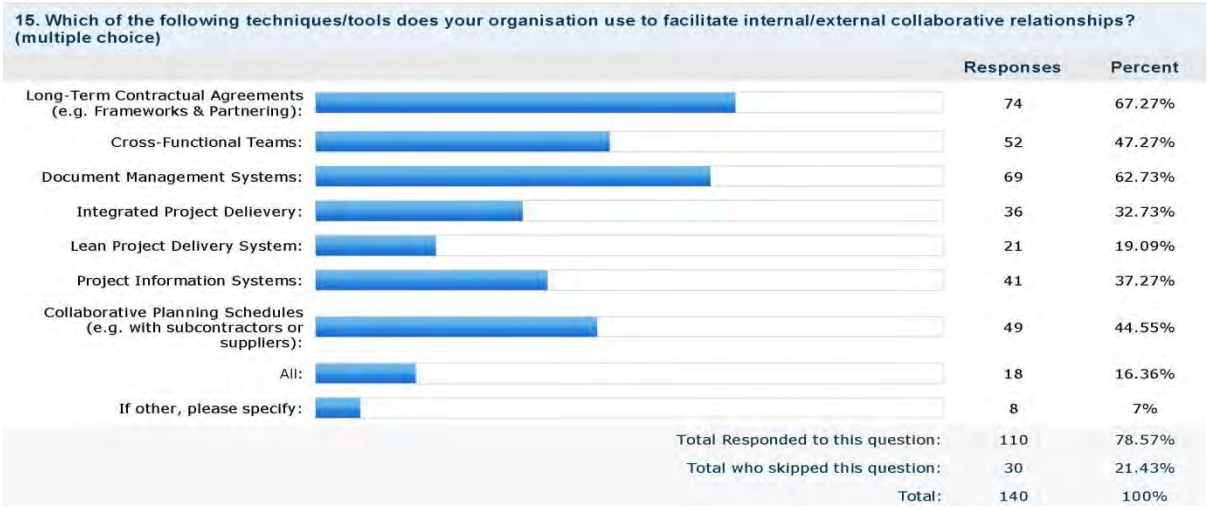
14. Has your organisation's leadership team been through any formal training/induction into Lean Thinking/methodology?

	Responses	Percent
No, the teams are satisfied, they do not need to know anything further on the subject:	48	43.64%
Some knowledge of Lean through training sessions which is adequate for involvement in Lean:	25	22.73%
Yes, and there is a general desire for increasing understanding but time pressure makes this difficult:	15	13.64%
Most members of the team have been through Lean awareness workshops:	12	10.91%
The leadership team fully understand the subject matter, and most team members have atleast a basic understanding:	10	9.09%
Total Responded to this question:	110	78.57%
Total who skipped this question:	30	21.43%
Total:	140	100%

Table 4.9, shows that almost 44% of all respondents acknowledged that teams within their organisations are satisfied and do not need to know anything further on the subject (statement 1). The median score for this question illustrates that the level of lean awareness and understanding within construction organisations is classified as „Learning".

Question 15

Table 4.10: Techniques used by construction organisations for developing collaborative relationships and partnerships (Author)



15. Which of the following techniques/tools does your organisation use to facilitate internal/external collaborative relationships? (multiple choice)

	Responses	Percent
Long-Term Contractual Agreements (e.g. Frameworks & Partnering):	74	67.27%
Cross-Functional Teams:	52	47.27%
Document Management Systems:	69	62.73%
Integrated Project Delievery:	36	32.73%
Lean Project Delivery System:	21	19.09%
Project Information Systems:	41	37.27%
Collaborative Planning Schedules (e.g. with subcontractors or suppliers):	49	44.55%
All:	18	16.36%
If other, please specify:	8	7%
Total Responded to this question:	110	78.57%
Total who skipped this question:	30	21.43%
Total:	140	100%

This question was introduced to identify the most common tools/techniques used by construction organisations in order to facilitate their internal and external collaborative relationships. Also, to see if organisations, involved in the study, have experience with the LPDS developed by the LCI; which is considered to be a new and better way to design and build capital facilities (Ballard, 2000). Some techniques were, to some extent similar to each other such as: Partnering, Integrated Project delivery (IPD) and the LPDS. What is most important, is selecting an effective collaborative approach that includes an early involvement of all participants using lean thinking through out the process; so it can enable them to reduce waste, maximise effectiveness; and thus optimise value to the client (Mossman, 2009).

Hence all of the tools/techniques given in the question are important and recommended for the successful implementation of LC, the participants had the chance to select more than once choice or select the „All" option. From the results shown in Table 4.10, very interestingly, all techniques/tools were selected with different proportions. About 32% of all respondents selected the IPD technique and 19% of them selected the LPDS technique. However, long-term contractual agreements, e.g. partnering and frameworks was identified as the most common technique used by organisations in order to facilitate their internal and external collaborative relationships, as it was selected by 67.27% of all respondents. This was followed by document management systems (62.73%), cross-functional teams (47.27%), and collaborative planning schedules (44.55%) respectively. On the other hand, only 8 respondents out of 110 selected the „other" option. This means that the study was able to define most of the collaborative tool/techniques that are widely used amongst construction organisations. However, these 8 respondents specified some valuable tools and techniques. For example: BIM for architectural models and for cross-discipline models; Last Planner; Lean Visual Management boards and meetings; Joint Strategic Planning; and Sustainable Procurement.

Question 16

Table 4.11: The level of awareness/understanding of the participants to some lean concepts and practices (Author)

16. To what extent do you agree/disagree with the following sentences?

	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree	Total
Lean concept is not suitable for the construction industry because of the demands from clients for quicker and cheaper projects:	2(1.8%)	12(10.81%)	17(15.32%)	35(31.53%)	45(40.54%)	111
There is no need to improve processes that are not presenting major problems:	3(2.7%)	6(5.41%)	11(9.91%)	61(54.95%)	30(27.03%)	111
Contract forms that allow one party to impose power over another, create adversarial relations. These adversarial relations create transaction costs, which are considered waste:	31(27.93%)	44(39.64%)	22(19.82%)	10(9.01%)	4(3.6%)	111
Lean has to be implemented across the business and value chain to deliver the promised results; any isolated efforts may even cause waste:	16(14.41%)	50(45.05%)	21(18.92%)	20(18.02%)	4(3.6%)	111
Using performance measurement for self-defence or evidence for claims and counter-claims is recommended:	6(5.41%)	33(29.73%)	35(31.53%)	28(25.23%)	9(8.11%)	111
The use of bills of quantity (BoQ) based on the Civil Engineering Standard Method of Measurement (CESMM), could lead to price variations and delivery difficulties:	8(7.21%)	23(20.72%)	45(40.54%)	33(29.73%)	2(1.8%)	111
Traditional performance preferences measured in projects, specifically costs and schedule, are not appropriate for continuous improvement:	5(4.55%)	34(30.91%)	16(14.55%)	50(45.45%)	5(4.55%)	110
All activities of the organisation/site should be continuously improved:	53(48.18%)	47(42.73%)	4(3.64%)	5(4.55%)	1(0.91%)	110
Quality should be first priority, not profit:	23(20.91%)	53(48.18%)	11(10%)	18(16.36%)	5(4.55%)	110
Any procurement form that tends to delegate design work to external designers, separates the design from the construction process; and therefore misses the lean aim of collaboration and integration:	16(14.55%)	44(40%)	28(25.45%)	17(15.45%)	5(4.55%)	110
Lean is more than tools or techniques; it requires a transformation in thinking, collaboration, flexibility, commitment, discipline, and a broad system-wide focus:	55(49.55%)	34(30.63%)	20(18.02%)	1(0.9%)	1(0.9%)	111
				Total Responded to this question:	111	79.29%
				Total who skipped this question:	29	20.71%

This question was introduced to assess the participants‟ level of awareness and understanding of some lean concepts and practices. Eleven statements were provided; and the respondents were asked to indicate their level of agreement/disagreement to each statement on a five-point Likert scale, ranging from „Strongly Agree‟ to „Strongly Disagree‟. Most statements were included in a positive form, which means that the respondents should have shown their agreement to them in order to provide answers that illustrates their awareness; while only three statements, particularly number 1, 2 and 5, were included in a negative form where respondents should have shown their disagreement to them to demonstrate their awareness. The modal responses of the participants are illustrated in Figure 4.1, and summarised in Tables 4.12 and 4.13 below.

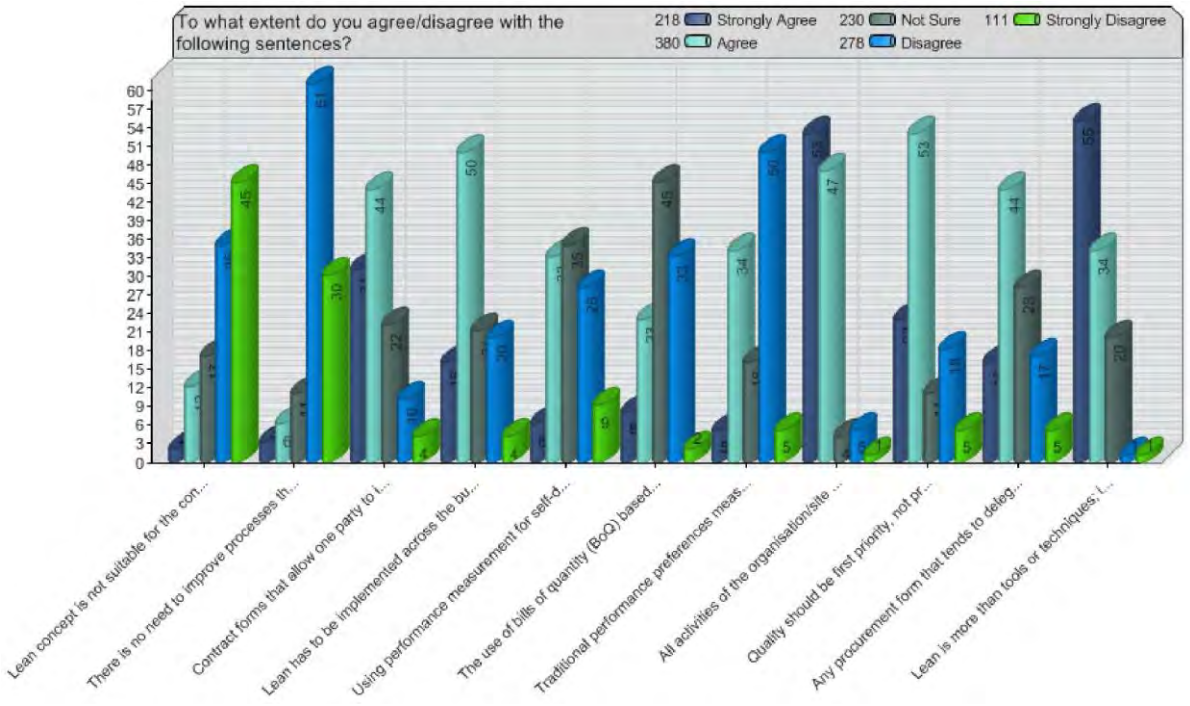


Figure 4.1: Modal responses of question 16, regarding some lean concepts (Author)

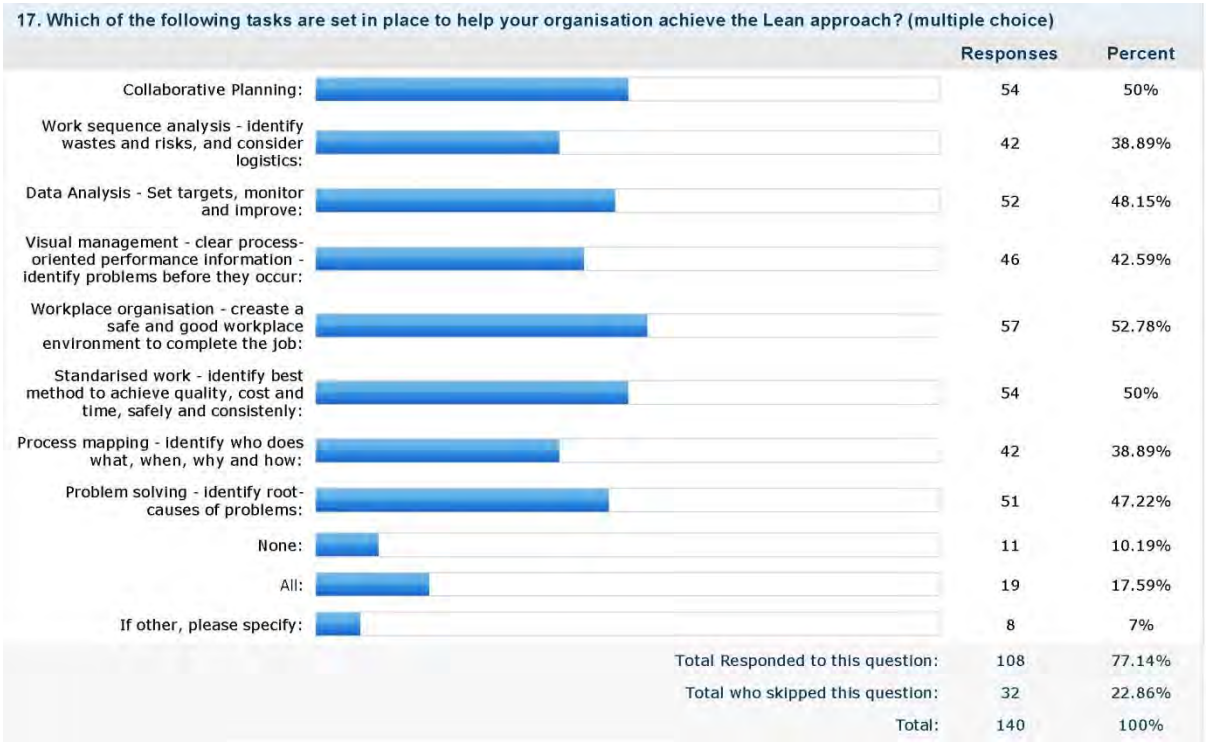
Table 4.12: Results of the statements that the participants should agree with (Author)							
ID	**The Aim of the statement**	**Answer Scale (5= Strongly Agree and 1= Strongly Disagree)**					**Freq. Score**
		5	**4**	**3**	**2**	**1**	**Aware (4 + 5)**
S3	To measure their awareness of the disadvantages of traditional contracts.	31	44	22	10	4	67.57%
S4	To measure their awareness of the importance of applying Lean on a broad system-wide focus.	16	50	21	20	4	59.46%
S6	To assess their awareness of the problems that exist with CESSM based bills, such as lack of transparency in the way that prices are made up as to the contractor‟s assumptions about profit and quality of work (See section 2.4.7).	8	23	45	33	2	27.93%
S7	To measure their understanding of the fact that traditional performance measures are backward focussed as they are not measured until project is complete; and thus information obtained arrives too to take any corrective actions (Alarcón & Serpell, 1996; Moon *et al.*, 2007). See section 2.5.2.	5	34	16	50	5	35.46%
S8	To evaluate their mentality of continuous improvement (Kaizen mentality).	53	47	4	5	1	90.91%
S9	To emphasise their acceptance/refusal for continuous improvement.	23	53	11	18	5	69.09%
S10	To measure their awareness of the disadvantages of traditional procurement methods	16	44	28	17	5	54.55%
S11	To evaluate their understanding of the importance of establishing a lean culture within organisations.	55	34	20	1	1	80.18%

Table 4.13: Results of the statements that respondents should disagree with (Author)							
ID	**The Aim of the statement**	**Answer Scale (5= Strongly Agree and 1= Strongly Disagree)**					**Freq. Score**
							Aware (1+2)
		5	**4**	**3**	**2**	**1**	
S1	To evaluate their understanding of the fundamental concepts and application of lean within construction companies.	2	12	17	35	45	72.07%
S2	To measure their level of lean commitment.	3	6	11	61	30	81.98%
S5	To measure their understanding of the fact that according to lean concepts, PMSs should be strongly related to „decentralised control" and used for continuous improvement and in the learning process at operational level; instead of being used for looking for who or what is to blame when problems occur (Lantelme & Formoso, 2000).	6	33	35	28	9	33.34%

As can be seen from Tables 4.12 and 4.13 above, the respondents were able to answer 8 statements out of 11 correctly. These are the statements where more than 50% of the respondents were able to demonstrate their awareness of lean concepts and practices. The shaded areas represent the other three statements (S5, S6, and S7) where more than 50% of the respondents were „not" aware of. The summation of all the frequency scores obtained divided by the number of given statements (11 in number) indicates that the respondents" average level of awareness/understanding of lean concepts and practices is equal to **61.14%.**

Question 17

Table 4.14: Tasks set in place to help construction organisations achieve the lean approach (Author)



All of the tasks shown in Table 4.14 are very essential and need to be set in place to enable construction organisations to progress along the lean journey. The results shown above could be classified into three different categories. The first is represented by those who selected the „All" option (17.59% of all respondents) and they are the most able to achieve the lean approach sustainably. The second is represented by those who selected „some" of the tasks with different proportions. However, it is noticeable that the task which received the highest amount of responses, workplace organisation, just achieved a percentage score of 52.78%. This was followed by collaborative planning (50%), and standardised work (50%) respectively. Then other tasks which were selected by less than half of the responses were: data analysis (48.15%), problem solving (47.22%), visual management (42.59%), work sequence analysis (38.89%), and process mapping (38.89%) in corresponding order.

Organisations are recommended to focus their efforts on practicing all of these fundamental tasks, and to establish a lean culture as this would be the best way towards the „sustainable" implementation of LC (Terry and Smith, 2011). Then, the third category was represented by those who selected the „None" option and they only stand for 10% of all respondents.

On the other hand, 7% of all respondents mentioned that their organisations use „other" tasks. This specification helped the study to identify some other excellent practices. Some of their comments and recommendations are as follows:

- Vision Creation - helping to identify the core purpose of what we are trying to achieve in order to do the right thing - not just do things right. More waste is spent doing the wrong thing right than doing right thing wrongly;
- This has been done on a relatively wide basis through a 5S approach in order to gain a wider understanding and buy in;
- The above are not implemented in the organisation that I work for, however, they are areas that I personally am seeking to develop where and when possible.

4.3.4 Hard aspects of lean: Questions 18-28

Many researchers identified the use of inappropriate tools and approaches as a barrier to the successful implementation of LC (Johansen *et al*., 2002; Bashir *et al*., 2010) An example of this is combining traditional techniques with those that are considered lean (Common *et al.*, 2000). These set of questions were introduced to identify and evaluate the tools/techniques (hard aspects of Lean) used by construction organisations for the implementation of lean. However, it is important to stress that the lean philosophy has to be clearly understood in order for these tools to be optimally utilised (Abdullah *et al.*, 2009). Focussing, only, on lean

tools may improve performance but it will not lead to long term sustainable improvement or yield to the full benefits of LC (Bashir *et al.*, 2010; Hines *et al.*, 2011).

Question 18

Table 4.15: Planning and control techniques used by construction organisations (Author)

18. Which Planning & Control tools/techniques are used by your organisation? (multiple choice)	Responses	Percent
Not Applicable:	19	17.59%
Critical Path Method:	68	62.96%
Look-Ahead Planning:	51	47.22%
Work-Flow Production management as a construction scheduling tool:	25	23.15%
Percentage Complete Planning Tools:	47	43.52%
Last Planner System:	21	19.44%
Constraint Analysis:	28	25.93%
Reverse-Phase Scheduling:	11	10.19%
If other, please specify:	12	11%
Total Responded to this question:	108	77.14%
Total who skipped this question:	32	22.86%
Total:	140	100%

The aim of this question was to identify the tools/techniques used by construction organisations for planning and control. According to the conceptual framework modified and developed by the author, the Last Planner System (LPS) was identified as the most suitable tool/technique for the successful implementation of LC. The LPS of production control is a tool/technique developed by the LCI, which concentrates on the planning function of construction using functions such as: Reverse Phase Scheduling (RPS), Look Ahead Planning, Constraint & Variance analysis and Percentage Plan Completed (PPC) charts (Salem *et al.*, 2006; Ansell *et al.*, 2007).

As can be seen from Table 4.15, the critical path method (CPM) received the highest proportion of selections (62.96%). The second most frequently used tool/technique was Look Ahead Planning (47.22%); and the PPC tools came third (43.52%). On the other side, only

19.44% of all respondents selected the LPS. Figure 4.2 below shows the arrangement of all the planning/control tools/techniques used by organisations within this study, according to their frequency of use.

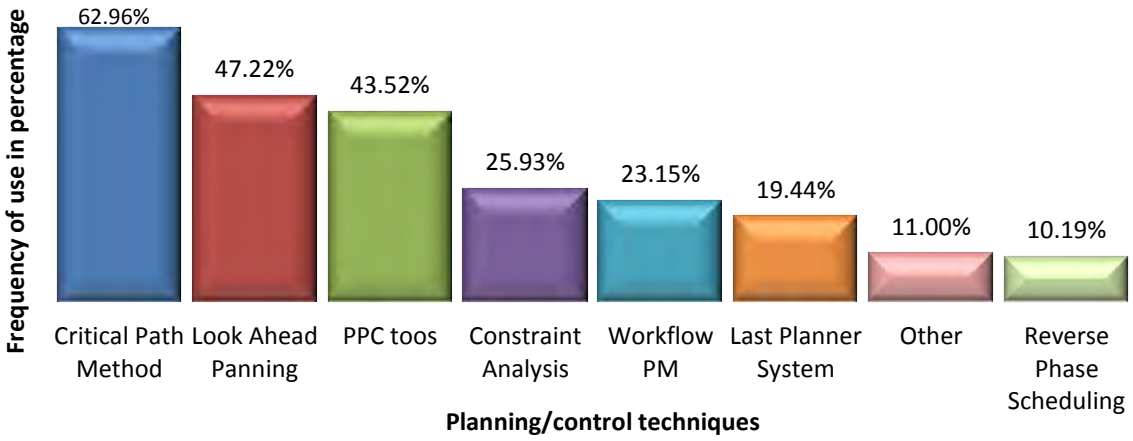


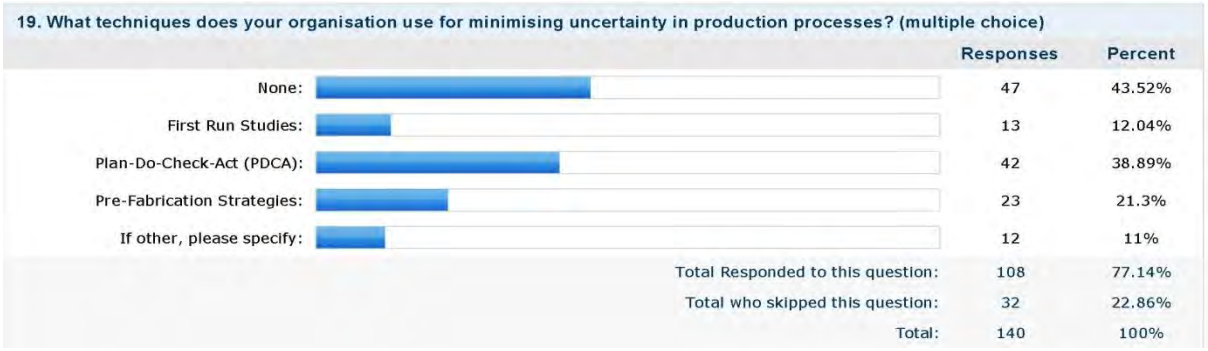
Figure 4.2: Comparison between planning and control tools/techniques used by construction organisations according to their frequency of use (Author)

Also, 11% of all respondents mentioned that their organisations use „other" tools/techniques. By specifying their answers, they helped the study to identify an important lean programming tool/technique which is the Line of Balance (LoB). The LoB is a planning/control tool that provides enormous visibility for the flows of work in a construction site; and can serve as a means to simulate and discuss different alternatives and strategies to sequence activities in the long run (Kemmer *et al.*, 2008). Some of the respondents" comments and recommendations are as follows:

- LoB, location based planning; Earned Value Analysis, & Constant Analysis of workload;
- Shouldn't Line of Balance programming also be one of the options here? LOB is one of the best Lean programming tools, as it is designed to optimise flow (unlike CPM).

Question 19

Table 4.16: Techniques used by construction organisations for minimising uncertainty in production processes (Author)

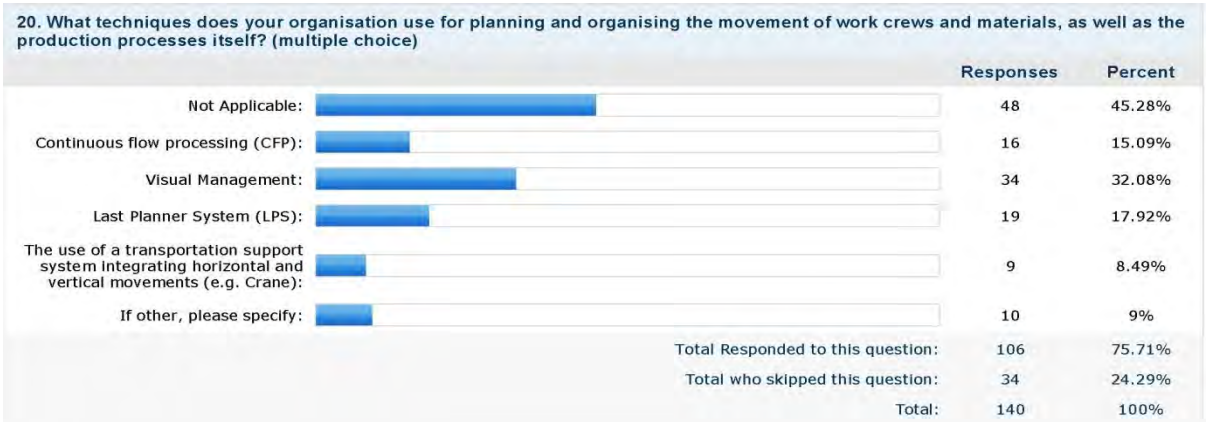


19. What techniques does your organisation use for minimising uncertainty in production processes? (multiple choice)	Responses	Percent
None:	47	43.52%
First Run Studies:	13	12.04%
Plan-Do-Check-Act (PDCA):	42	38.89%
Pre-Fabrication Strategies:	23	21.3%
If other, please specify:	12	11%
Total Responded to this question:	108	77.14%
Total who skipped this question:	32	22.86%
Total:	140	100%

The aim of this question was to indentify the techniques that construction organisations use for reducing uncertainty in production processes. As can be seen from Table 4.16, 43.52% of the respondents acknowledged that no techniques are used in their organisation for that purpose, while 38.89% selected the PDCA technique. Also, prefabrication strategies and first run studies were selected by 21.3% and 12.04% of all respondents respectively. On the other hand, many of the respondents who selected the „Other" option stated that they are not sure, do not know, question not applicable, or that production is not their main concern.

Question 20

Table 4.17: Techniques used by construction organisations for planning and organising the movement of crews and materials, as well as the production processes itself (Author)



20. What techniques does your organisation use for planning and organising the movement of work crews and materials, as well as the production processes itself? (multiple choice)	Responses	Percent
Not Applicable:	48	45.28%
Continuous flow processing (CFP):	16	15.09%
Visual Management:	34	32.08%
Last Planner System (LPS):	19	17.92%
The use of a transportation support system integrating horizontal and vertical movements (e.g. Crane):	9	8.49%
If other, please specify:	10	9%
Total Responded to this question:	106	75.71%
Total who skipped this question:	34	24.29%
Total:	140	100%

As can be seen from Table 4.17, many of the respondents selected the „Not Applicable" option (45.28% of all respondents). Alternatively, it is noticeable that visual management is the most commonly used technique (32.08%). The LPS came second (17.92%). It is important to note that the number of respondents who selected LPS in question 18 is almost as many as those who selected LPS in this question. Subsequently, CFP and the use of Crane represented 15.09% and 8.49% of all respondents respectively. Alternatively, 9% of the respondents selected the „Other" option. When specifying their answers, the author noted that some of them are not sure about this question, some mentioned traditional practices, and others identified some valuable techniques. To see the full list, please refer to the „Survey Report" in Appendix 12). Some of the comments which identified good practices are as follows: Line of balance (LoB), Virtual design and construction (VDC), Value Stream Mapping (VSM); and Logistics Plans.

Question 21

Table 4.18: The proportion of construction organisations that have 'successful' experience with the management concepts of: TQM, SCM and CE (Author)

21. Does your organisation have 'successful' experience with any of the following management concepts: Supply Chain Management (SCM), Concurrent Engineering (CE), Total Quality Management (TQM)?

	Responses	Percent
No:	57	53.77%
If yes, please identify which?:	49	46.23%
Total Responded to this question:	106	75.71%
Total who skipped this question:	34	24.29%
Total:	140	100%

This question was introduced to identify the amount of construction organisations which have successful experience with the principles of total quality management (TQM), supply-chain management (SCM), and concurrent engineering (CE). As can be seen from Table 4.18, about 46% of the organisations within this study have or have previously had successful experience with one or more of the following management concepts: TQM, SCM and CE;

while around 54% have not had successful experience with any of them. Respondents who selected the „Yes" option, were also asked to identify which of the three mentioned management concepts (SCM, CE and SCM) they had successful experience with. The results (Appendix 12) showed that most of the respondents who selected the „Yes" option identified TQM, and some mentioned SCM, while only a very few respondents (about 4% of those who selected „Yes") have or have had previous successful experience with the CE concept.

Question 22

Table 4.19: Techniques used by suppliers for the provision of materials to construction sites (Author)

22. Which of these techniques do your suppliers use for the provision of materials to your construction sites? (multiple choice)

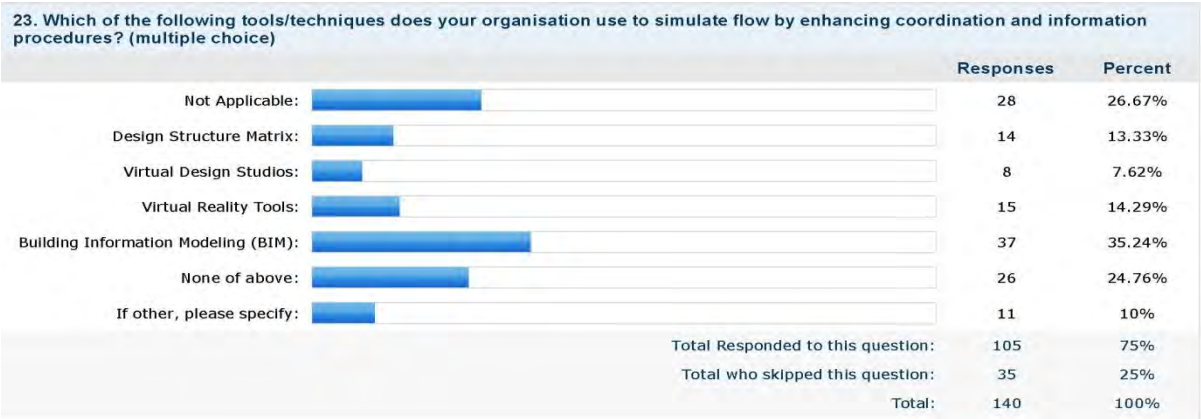
	Responses	Percent
Not Applicable:	27	25.47%
Just-In-Time:	32	30.19%
Kanban System:	5	4.72%
Value Stream Analysis:	10	9.43%
Don't know:	36	33.96%
If other, please specify:	9	8%
Total Responded to this question:	106	75.71%
Total who skipped this question:	34	24.29%
Total:	140	100%

This question was introduced to identify the techniques used by the suppliers (of the organisations within this study) for the provision of materials to construction sites. As can be seen from Table 4.19, almost 34% of the respondent had no idea (didn"t know), and the question was not applicable to about 25% of the respondents. However, 30.19% of the respondents selected the JIT approach. Value stream analysis and the Kanban system techniques are not widely practiced as they were selected by only 9.43% and 4.72% of all respondents respectively. Also, 8% of the respondents selected the „Other" option and were required to specify their answers (to see the full list, please refer to Appendix 12). Below are some interesting comments:

- Still in the process of aligning the suppliers with organizations‟ Lean strategy;
- Our Logistics Plan and Last Planner;
- Traditional (wasteful);
- Wouldn't call it "Just-in-time" it's not as formalised as that, however materials are ordered in accordance with our project team's programmes.

Question 23

Table 4.20: Tools/techniques used by construction organisations to simulate flow by enhancing coordination and information procedures (Author)



23. Which of the following tools/techniques does your organisation use to simulate flow by enhancing coordination and information procedures? (multiple choice)

	Responses	Percent
Not Applicable:	28	26.67%
Design Structure Matrix:	14	13.33%
Virtual Design Studios:	8	7.62%
Virtual Reality Tools:	15	14.29%
Building Information Modeling (BIM):	37	35.24%
None of above:	26	24.76%
If other, please specify:	11	10%
Total Responded to this question:	105	75%
Total who skipped this question:	35	25%
Total:	140	100%

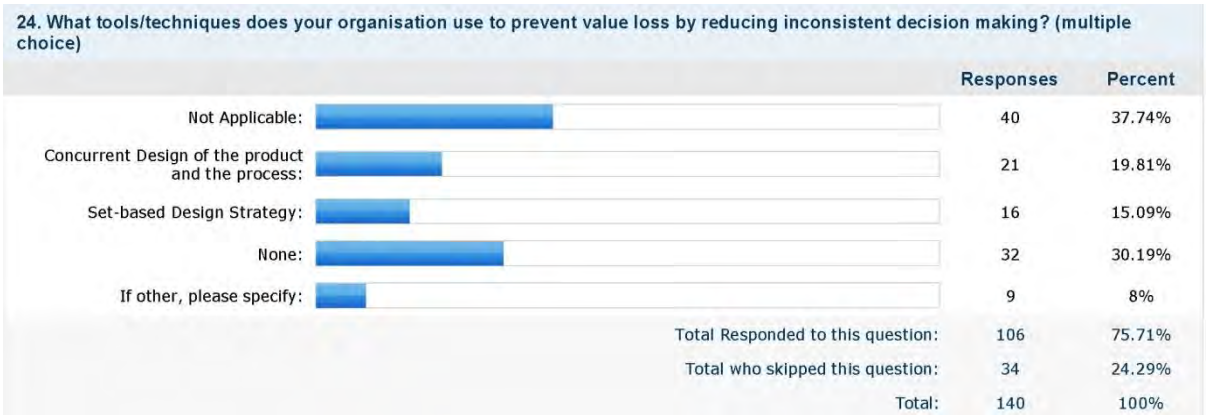
From Table 4.20, it is obvious that BIM is the most common tool/technique used by organisations to simulate flow by enhancing coordination and information procedures; however it was selected by only 35.29% of all respondents. Then, virtual reality (VR) tools, design structure matrix (DSM), and virtual design studios (VDS) which were selected by 14.29%, 13.33%, and 7.62% of all respondents respectively. Alternatively, 26.67% of the respondents mentioned that the question was not applicable to them; and 24.76% of the respondents acknowledged that „None‟ of the tools/techniques mentioned in this question were used by their organisations. Additionally, 10% of the respondents selected the „Other‟ option and specified their answers (to see the full list, please refer to Appendix 12). Some of

the respondents mentioned that: they do not know, BIM is rarely used in practices, or some limited BIM but not extensively. Some others identified tools such as CAD and 3D modelling. However, a number of the respondents highlighted some interesting lean tools/techniques such as:

- SMED at the moment with plans to integrate Virtual Reality Tools through a real time reporting Management Information System. SMED is an abbreviation to Single-Minute Exchange of Die, and it is a lean production method used for continuous improvement;
- DSM only in design, plus Last Planner;
- Daily coordination meetings followed by Lean daily management Meeting involving all.

Question 24

Table 4.21: Tools/techniques used by construction organisations to prevent value loss by reducing inconsistent decision making (Author)



24. What tools/techniques does your organisation use to prevent value loss by reducing inconsistent decision making? (multiple choice)

	Responses	Percent
Not Applicable:	40	37.74%
Concurrent Design of the product and the process:	21	19.81%
Set-based Design Strategy:	16	15.09%
None:	32	30.19%
If other, please specify:	9	8%
Total Responded to this question:	106	75.71%
Total who skipped this question:	34	24.29%
Total:	140	100%

The aim of this question was to identify the tools/techniques used by organisations to prevent value loss by reducing inconsistent decision making. As can be seen from Table 4.21, most of the respondents selected the „Not Applicable" and „None" options respectively. On the other hand, about 20% of the respondents mentioned that concurrent design of the product and the process is used within their organisations, and only 15.09% went for set-based design

strategies. Additionally, 8% of the respondents (9 respondents in number) preferred to choose the „Other" option. 5 respondents out of 9 stated that they do not know, not sure, none is used, or that it is just done by experience.

Question 25

Table 4.22: Areas of application of LPS within construction organisations (Author)

This question was introduced to identify how LPS for production control is being used within organisations. Also, to determine whether organisations are fully aware of the different aspects of LPS and the full potential of Lean or if LPS is just seen by them as an activity scheduling tool.

The respondents had the chance to choose more than one answer. However, as can be seen from Table 4.22, more than half (60.95%) of the respondents stated that the question is „Not Applicable". The second highest proportion or responses were for using LPS for planning as an activity scheduling tools (25.46%). Performance measurement & organisational learning (19.05%) and management control (18.1%) ranked 3rd and 4th respectively. Then, production

control (16.19%) and tuning logistics operation during production control (14.29%) ranked 5th and 6th correspondingly. The „Other" option figured at the bottom of the list and received only 5 responses out of 105. Figure 4.3 below shows the arrangement of the different areas of application of LPS, according to their frequency of use within construction organisations involved in this study.

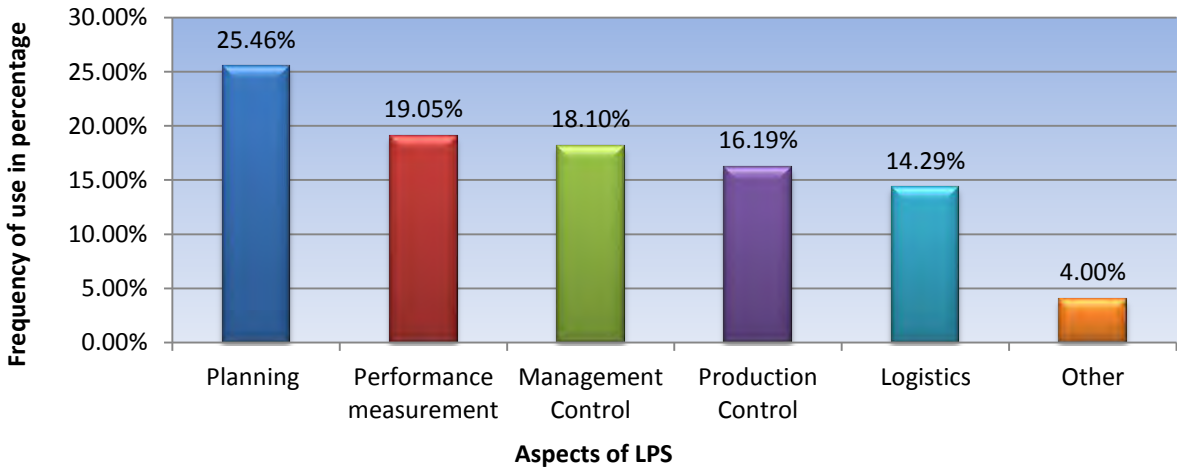


Figure 4.3: Areas of application of LPS within construction organisations (Author)

Question 26

Table 4.23: Testing the understanding/awareness to the function of the PPC value within the LPS (Author)

26. In Last Planner, the Percentge Plan Complete (PPC) value:

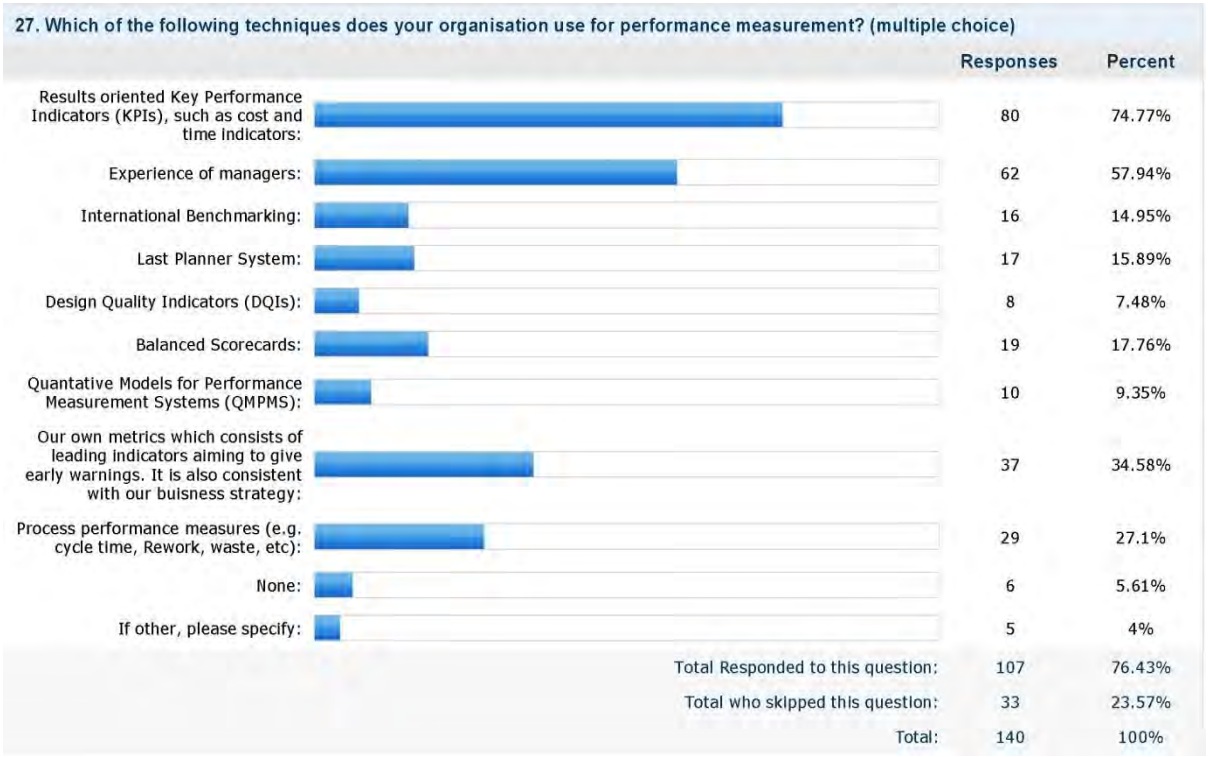
	Responses	Percent
measures the level of utilization of a work flow (efficiency).:	3	2.88%
measures production planning effectiveness and workflow reliability:	16	15.38%
Both of above:	20	19.23%
Not Applicable:	65	62.5%
Total Responded to this question:	104	74.29%
Total who skipped this question:	36	25.71%
Total:	140	100%

LC practitioners refer to the percentage plans complete (PPC) value in LPS as a metric for commitment reliability. However, it is very important to clarify that the PPC value does not measure the level of utilization of a work flow (efficiency). Instead it measures production planning effectiveness and workflow reliability (Forbes & Ahmed, 2011).

The aim of this question was to examine the respondents‟ awareness/understanding to the function of the PPC value when using the LPS. As can be seen from Table 4.23 above, more than half of the respondents (62.5%) mentioned that the question is not applicable to them; and 22.11% of the respondents provided a wrong answer. On the other hand, only 16 respondents out of 104 (15.38%) were able to answer the question correctly.

Question 27

Table 4.24: Techniques used by construction organisations for performance measurement (Author)



27. Which of the following techniques does your organisation use for performance measurement? (multiple choice)

	Responses	Percent
Results oriented Key Performance Indicators (KPIs), such as cost and time indicators:	80	74.77%
Experience of managers:	62	57.94%
International Benchmarking:	16	14.95%
Last Planner System:	17	15.89%
Design Quality Indicators (DQIs):	8	7.48%
Balanced Scorecards:	19	17.76%
Quantative Models for Performance Measurement Systems (QMPMS):	10	9.35%
Our own metrics which consists of leading indicators aiming to give early warnings. It is also consistent with our buisness strategy:	37	34.58%
Process performance measures (e.g. cycle time, Rework, waste, etc):	29	27.1%
None:	6	5.61%
If other, please specify:	5	4%
Total Responded to this question:	107	76.43%
Total who skipped this question:	33	23.57%
Total:	140	100%

This question was introduced to identify the techniques used by organisations for performance measurement. Some of the PMSs included were traditional or consist of results based indicators (e.g. depending on the experience of managers and results based KPIs such as cost and time indicators), while others were process oriented or consist of leading indicators (e.g. process performance measurement, LPS, and balanced scorecards).

As can be seen from table 4.24 above, results oriented KPIs are the most common technique used for performance measurement (selected by 74.77% of all respondents). Then, 57.94% of the respondents went for using experience of managers as a means for performance measurement. Also, 34.58% of the respondents acknowledged that their organisations utilise their own metrics which consists of leading indicators aiming to give early warning; and which is also consistent with their business strategy. The 4th highest proportion of responses was for process performance measures (27.1%), e.g. cycle time, waste, rework, etc. Other performance measurement techniques such as: balanced score cards, LPS, international benchmarking received 17.76%, 15.89%, and 14.95% of all responses respectively. On the other hand, the results show that QMPMS and DQIs are the least practiced as they were selected by only 9.35% and 7.48% of all respondents correspondingly.

Figure 4.4 below shows the arrangement of all these performance measurement techniques according to their frequency of use. Alternatively, only 5.61% of the respondents mentioned that none of these techniques are used by their organisations. Also, only 4% of all respondents selected the „Other" option; and their comments were as follows:

- External consultants, Nisus, to carry out independent client surveys and interviews;
- These are measured in some areas, and I plan to incorporate a number of these so the business can effectively make decisions in order to continuously improve;

- Customer Feedback; Client satisfaction and repeat bookings.

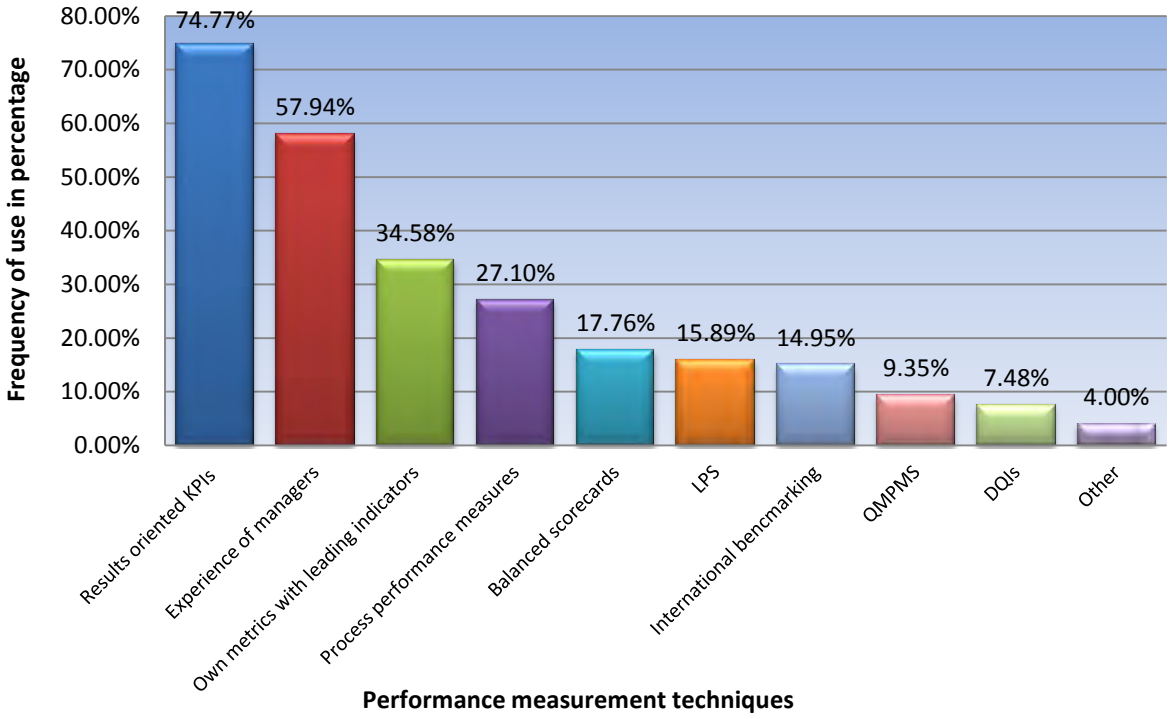


Figure 4.4: Techniques used by construction organisations for performance measurement (Author)

Question 28

Table: 4.25: Prioritising non-financial performance measures according to their importance to construction organisations (Author)

28. Please score out of 10 each of the following 'Non - Financial' performance measures, according to their importance (10 being the most important and 1 being the least important).		
Quality:		
Safety:		
Client/customer satisfaction:		
Functionality:		
Planning Efficiency:		
Team Performance:		
Productivity:		
Total Responded to this question:	107	76.43%
Total who skipped this question:	33	23.57%
Total:	140	100%

As shown in Table 4.25 above, the aim of this question was to prioritise and identify the significant „non-financial" performance measures (leading indicators) that are appropriate for continuous improvement, according to their importance to organisations. Figure 4.5 below shows the ranking of the performance measures, according to their importance, based on the viewpoints of the respondents.

The respondents were asked to rate the given non-financial performance measures on a ten-point scale to indicate the level of importance (10 being the most important and 1 being the least important). The mean values of the given non-financial performance measures were then determined to indicate the degree of importance of these performance measures to construction organisations from the perspective of the respondents. If the mean value scored „8" or above to a particular performance measure, then it would be classified as a significant performance measure. In similar research, Cheng (2001) and Chan et al. (2003) represented the level of significance on a five-point Likert scale by a score of „4" (Lam et al., 2007). The results of the mean value scores are summarised in Table 4.26. To see individual entries, please refer to the survey report in Appendix 12.

Table 4.26: Mean values of non-financial performance measures for construction organisations (Author)

Non-financial performance measures	Mean value score out of 10
Quality	8.775
Safety	9.504
Client/customer satisfaction	9.149
Functionality	7.654
Planning Efficiency	7.607
Team Performance	7.803
Productivity	7.785

Note: The shaded areas represent the significant performance measures.

As can be seen from Table 4.26 above, the mean values of quality, safety and client satisfaction exceed the cut-off point (a score of 8) and thus are considered as the significant (most important) non-financial performance measures for construction organisations.

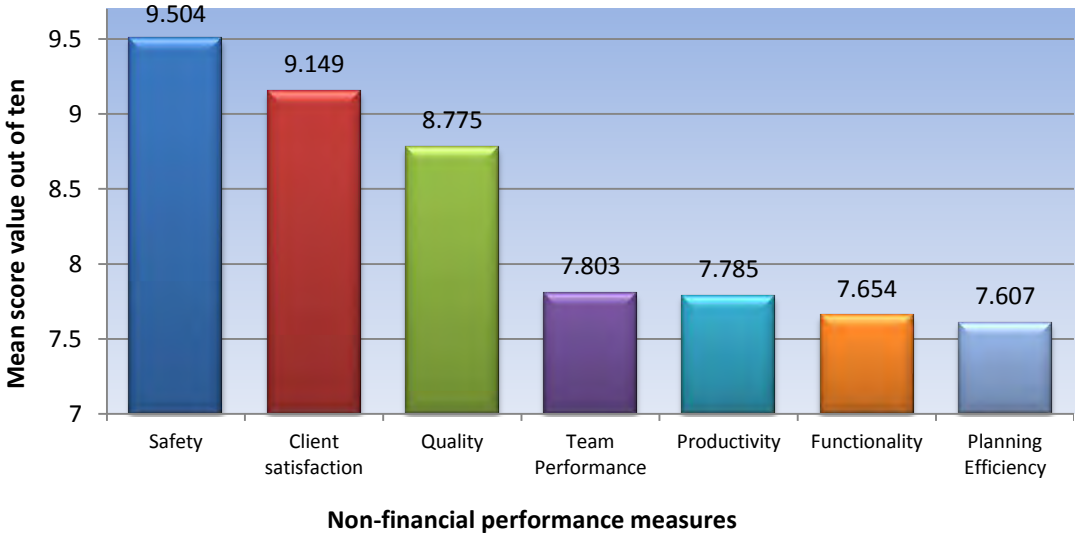


Figure 4.13: Ranking of non-financial measures according to their importance to construction organisations (Author)

A reliability test was also conducted for this question and Cronbach‟s Alpha value was found to be 0.832 (See Appendix 13); which indicates a high degree of reliability, as a value ≥ 0.7 is considered to be acceptable (Lam *et al.*, 2007).

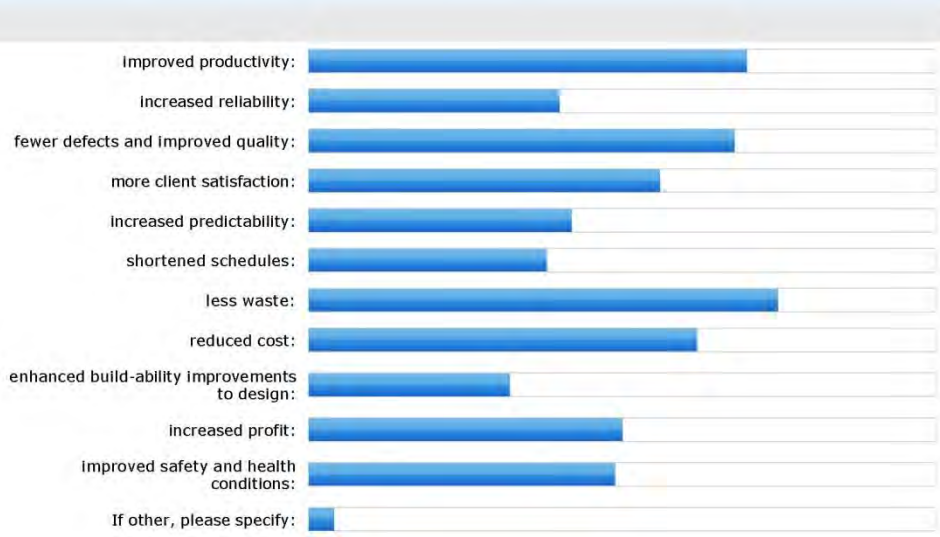
4.3.5 Outcomes of the successful implementation of LC: Questions 29-33

These set of questions were introduced to assess the participants‟ realisation to the benefits of the successful implementation of LC. Also to identify some of the good practices executed by organisations in order to contribute to the triple bottom line of environmental, social and economic sustainability. Finally, to recognize the reasons that could „pull‟ construction organisations to decide to go on the „Lean‟ joumey.

Question 29

Table 4.27: Identifying the top five benefits that could be achieved from applying lean principles to construction (Author)

29.
Which of the following benefits could be achieved from applying lean principles to construction? (Please choose Up to 5 benefits only)



	Responses	Percent
improved productivity:	74	70.48%
increased reliability:	42	40%
fewer defects and improved quality:	71	67.62%
more client satisfaction:	59	56.19%
increased predictability:	44	41.9%
shortened schedules:	40	38.1%
less waste:	79	75.24%
reduced cost:	65	61.9%
enhanced build-ability improvements to design:	34	32.38%
increased profit:	52	49.52%
improved safety and health conditions:	51	48.57%
If other, please specify:	5	4%
Total Responded to this question:	105	75%
Total who skipped this question:	35	25%
Total:	140	100%

An extensive literature review was conducted to understand the expected benefits from LC. Based on that, this question was designed to assess the participants‟ realisation to the benefits of applying lean principles to construction. The „Other‟ option was added to help the study to define any other possible benefits. The respondents were requested to express their opinions to the best of their knowledge about the benefits that could be achieved from applying lean principles to construction. However, to make the question more challenging, the respondents were asked to choose up to five benefits only.

As can be seen from Table 4.27 above, the top five benefits that could be achieved from applying lean principles to construction, according to the respondents‟ perspectives are as follows:

1. Less waste (75.24%);
2. Improved productivity (70.48%);
3. Fewer defects and improved quality (67.72%);
4. Reduced cost (61.9%); and
5. More client satisfaction (56.19%).

Additionally, 4% of the respondents (5 out of 105) selected the „Other" option. This helped the study to identify more expected benefits, such as: collaboration between SC members; Positive recognition, increased innovation, more workplace satisfaction and pride; and Long-term financial benefits, not necessarily short-term profit.

Questions 30, 31, &32

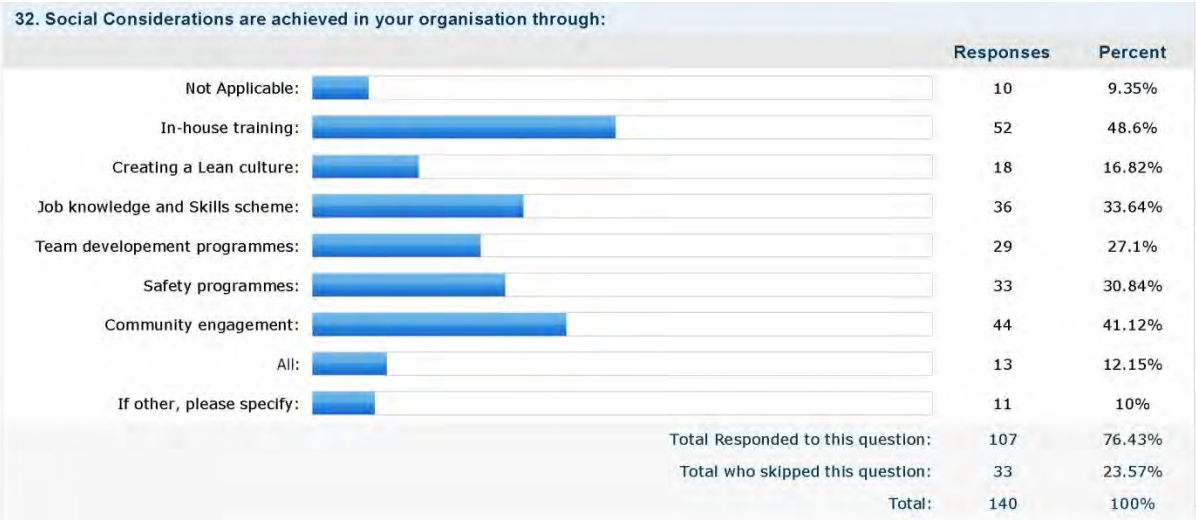
Table 4.28: Practices executed by organisations to help it contribute to the triple bottom line of economical, environmental, and social sustainability (Author)

30. Economic success is achieved in your organisation through:

	Responses	Percent
Risk management and mitigation:	57	54.29%
Lean Construction:	18	17.14%
Supply-chain assistance:	25	23.81%
Cost and Value Management:	58	55.24%
All:	27	25.71%
If other, please specify:	7	6%
Total Responded to this question:	105	75%
Total who skipped this question:	35	25%
Total:	140	100%

31. Environmental considerations are achieved in your organisation through:

	Responses	Percent
Not Applicable:	16	15.24%
International standards and accreditation, such as the ISO 14001:	52	49.52%
BRE Environmental Assessment Model (BREEAM):	41	39.05%
Supply chain assistance:	22	20.95%
Lean Construction as a primary tool for reducing physical waste:	14	13.33%
All:	11	10.48%
If other, please specify:	8	7%
Total Responded to this question:	105	75%
Total who skipped this question:	35	25%
Total:	140	100%

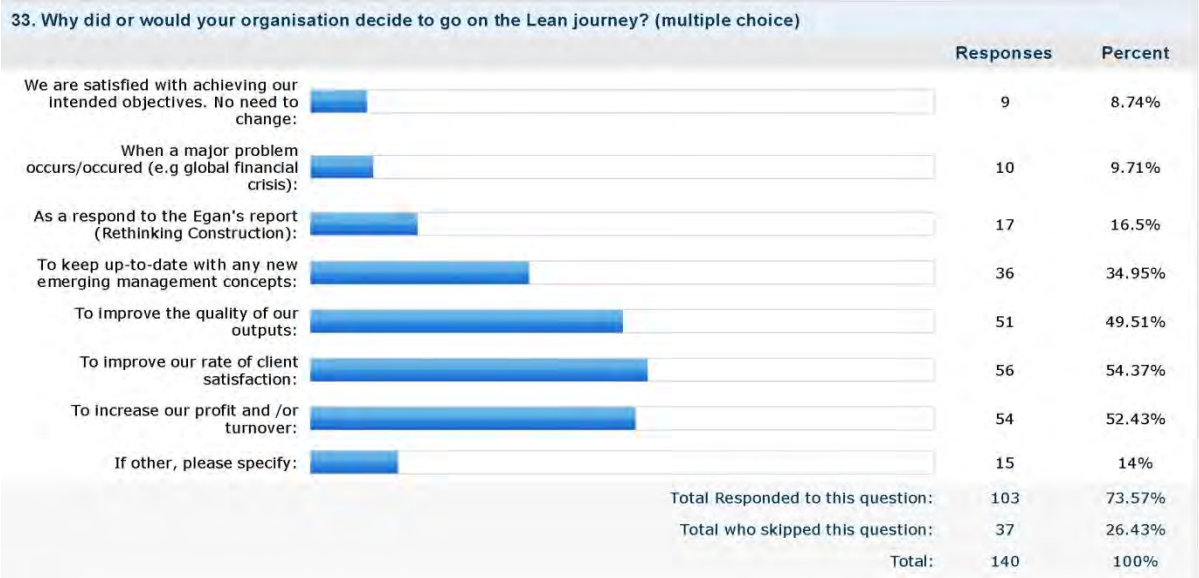


These three questions were introduced to see if the respondents are aware of the full potential of Lean & the importance of supply chain management, and whether there is a holistic view of lean within construction organisations or not. A summary of the analysis is provided below.

As can be seen from Table 4.28 above, cost & value management and risk management & mitigation are the most common approaches used by construction organisations for achieving economical success. Only 17.14% of all of the respondents stated that their organisations are achieving economical benefits through using LC, and just 25% selected the „All option". International standards and BREEAM are the top two approaches used for economical considerations. Only 13.33% of all respondents considered using LC as a primary tool for reducing physical waste, and just 10.33% selected the „All" option. As for social considerations, in-house training & community engagement are the most common approaches used by construction organisations for obtaining social benefits to their employees. Only 16.82% of all respondents mentioned the establishment of a Lean culture. It also appears from the responses that supply-chain assistance is overlooked or ignored by most organisations, as it was selected by no more than 24% of all respondents.

Question 33

Table 4.29: The top reasons that 'pulled' or would 'pull' construction organisations to the Lean journey (Author)



33. Why did or would your organisation decide to go on the Lean journey? (multiple choice)

	Responses	Percent
We are satisfied with achieving our intended objectives. No need to change:	9	8.74%
When a major problem occurs/occured (e.g global financial crisis):	10	9.71%
As a respond to the Egan's report (Rethinking Construction):	17	16.5%
To keep up-to-date with any new emerging management concepts:	36	34.95%
To improve the quality of our outputs:	51	49.51%
To improve our rate of client satisfaction:	56	54.37%
To increase our profit and /or turnover:	54	52.43%
If other, please specify:	15	14%
Total Responded to this question:	103	73.57%
Total who skipped this question:	37	26.43%
Total:	140	100%

The aim of this question was to identify the reasons that could „PULL" organisations to the „Lean" journey. Also, to determine if organisations are reluctant to change (i.e. stuck to their current management concepts) or not, by giving them the option to choose that they are satisfied with achieving their intended objectives, and thus no need to change. In addition, the „Other" option was included to help the study to identify any other potential reasons. Please note that the word „any" was added to the option of keeping up to date with new emerging management concepts. It is right to keep up to date with new concepts but not just with „any".

From Table 4.29, it is very obvious that there are three top reasons that would attract or pull organisations to the Lean journey. These are:

1) To improve their rate of client satisfaction (received 54.37% of all responses);
2) To improve their profit and/or turnover (received 52.43% of all responses);
3) To improve the quality of their outputs (received 49.51% of all responses).

Also, about 35% of the respondents stated that their organisation would possibly go on the Lean journey to keep up to date with any new management concepts, and 16.5% mentioned that this happened/would happen as a response to the Egan‟s report. Additionally 9.71% acknowledged that their organisations will not take this step unless a major crisis occurs. Furthermore, only 8.74% of the respondents admitted that there is no need o change as they believe that they are already satisfied with achieving their intended objectives. On the other hand, 14% of the respondents selected the „Other‟ option. This helped the study to identify some other possible reasons. Some of the comments received were as follows:

- To reduce waste and therefore improve the social and environmental integrity of the organisation;
- Improve predictability of delivery and to support internal continuous improvement focus;
- To improve the certainty of outcome;
- To create safer operations to reduce stress on project managers;
- Just to expand the client satisfaction - all stakeholders. Also, to gain a competitive edge;
- They are not clued up enough to even think about lean procedures;
- The organisation talks the talk when required but is not actively engaging with lean processes.

4.3.6 Barriers to the successful implementation of LC: Questions 34-35

Question 34 was introduced to see if the real world agrees with the author‟s identification of they Key barriers to LC; also, to prioritise the barriers identified, and evaluate its effect on the successful implementation of LC. In addition, question 35 was added to help the study identify and consider any other possible barriers from the respondents‟ view.

Question 34

Table 4.30: Barriers to the successful implementation of Lean Construction (Author)

34. To what extent do you agree that the following issues are considered barriers to the successful implementation of Lean Construction?

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Fragmentation & subcontracting:	26(23.85%)	49(44.95%)	23(21.1%)	10(9.17%)	1(0.92%)	109
Procurement & contracts:	22(20.18%)	47(43.12%)	30(27.52%)	10(9.17%)	0(0%)	109
Lack of adequate Lean awareness & understanding:	50(45.05%)	48(43.24%)	11(9.91%)	1(0.9%)	1(0.9%)	111
Culture & human attitudinal issues:	35(31.53%)	54(48.65%)	15(13.51%)	6(5.41%)	1(0.9%)	111
Time & commercial pressure:	29(26.36%)	51(46.36%)	19(17.27%)	9(8.18%)	2(1.82%)	110
Financial issues:	17(15.32%)	43(38.74%)	29(26.13%)	20(18.02%)	2(1.8%)	111
Lack of top management committment:	42(37.84%)	44(39.64%)	16(14.41%)	8(7.21%)	1(0.9%)	111
Design/Construction dichotomy:	20(18.69%)	34(31.78%)	30(28.04%)	18(16.82%)	5(4.67%)	107
Educational issues:	18(16.51%)	52(47.71%)	23(21.1%)	13(11.93%)	3(2.75%)	109
Lack of process based performance measurement systems:	16(14.55%)	49(44.55%)	30(27.27%)	12(10.91%)	3(2.73%)	110
				Total Responded to this question:	111	79.29%
				Total who skipped this question:	29	20.71%
				Total:	140	100%

The main aims of this question were to identify the key barriers based on the participants‟ view; and to prioritise the barriers in order to evaluate its effect on the successful implementation of LC.

As can be seen from Table 4.30, the respondents were asked to rate each barrier on a five-point Likert scale to indicate the level of influence, ranging from „‟5‟‟ equal to strongly agree to „‟1‟‟ equal to strongly disagree. The data received were then entered into the Statistical package for Social Science (SPSS 19.0) software to analyse the results and to evaluate its reliability. Consequently, the mean values of the given barriers were then determined to indicate the level of influence of these barriers on the successful implementation of LC from the respondents‟ perspective. If the mean value scored „‟4‟‟ or above to a particular barrier,

then it would be classified as a significant barrier. In previous research, the level of significance on a five-point Likert scale was represented by a score of „‟4‟‟ (Abdullah *et al.*, 2009).

Regarding the reliability test, the coefficient obtained a value of 0.747. This indicates the reliability of the results because a Cronbach Alpha value greater than or equal to 0.7 is considered to be acceptable (Lam *et al.*, 2007; Ab Rahman *et al.*, 2011).

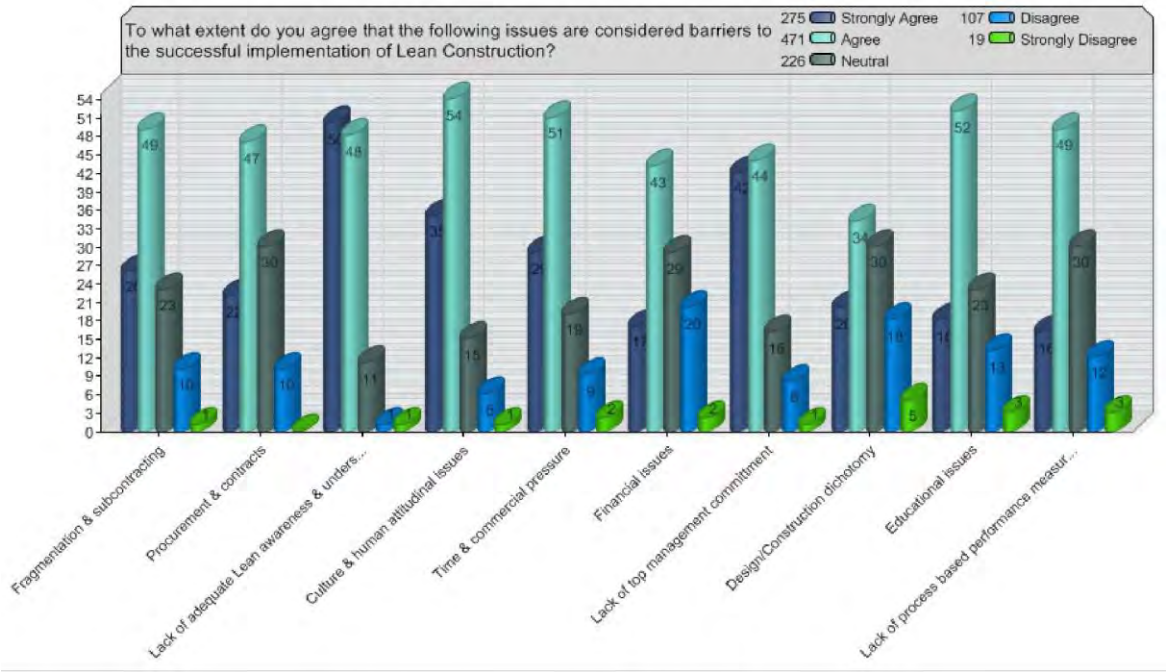


Figure 4.14: The frequency output of the barriers to the successful implementation of Lean Construction, based on the respondents' viewpoint (Author)

The results of the frequency analysis are shown in Figure 4.14 & Table 4.31. To see the complete set of analysis including the one sample T test, reliability test, and detailed frequency tables and histograms please refer to the SPSS statistical analysis in Appendix 13.

Table 4.31: Frequency analysis of the barriers to the successful implementation of Lean Construction (Author)					
ID	**Barriers to the successful implementation of Lean Construction**	**Mean**	**Median**	**Mode**	**Std. deviation**
B1	Fragmentation & subcontracting	3.7658	4.0000	4.0000	0.99959
B2	Procurement & contracts	3.6937	4.0000	4.0000	0.95148
B3	Lack of adequate Lean awareness & understanding	4.3063	4.0000	5.0000	0.76030
B4	Culture & human attitudinal issues	4.0450	4.0000	4.0000	0.86747
B5	Time & commercial pressure	3.8919	4.0000	4.0000	0.97562
B6	Financial issues	3.4775	4.0000	4.0000	1.01665
B7	Lack of top management commitment	4.0631	4.0000	4.0000	0.94657
B8	Design/Construction dichotomy	3.3423	3.0000	4.0000	1.18702
B9	Educational issues	3.5856	4.0000	4.0000	1.03983
B10	Lack of process based PMS	3.5495	4.0000	4.0000	0.98847

Note: The shaded areas represent the significant barriers identified.

As can be seen from Table 4.31, the mean values of three barriers, namely: B3, B4 and B7 exceeded the cut-off point (a mean score of 4.0 and above) and thus are considered as the significant barriers to the successful implementation of LC. It is also noticeable that these three barriers obtained the lowest standard deviations, which suggests that the participants were quite certain about these barriers more than all the others. Figure 4.15 below shows the ranking of all of the barriers, according to their influence, based on their mean values out of five.

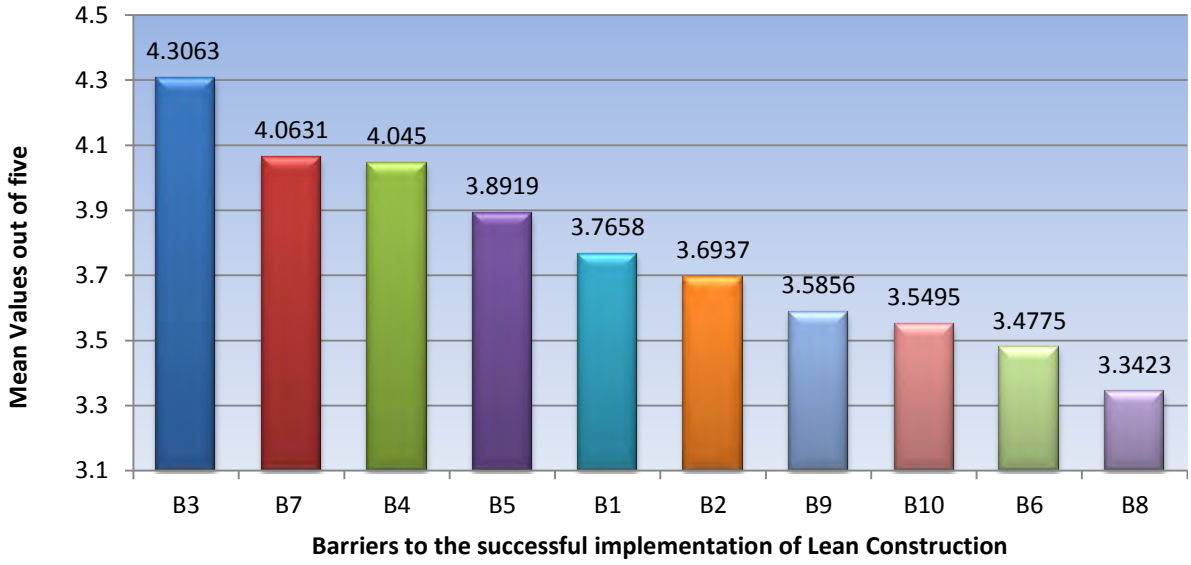


Figure 4.15: The ranking of the barriers identified according to their influence on the successful implementation of Lean Construction, from the respondents' perspective (Author)

Question 35

Table 4.32: Other barriers to the implementation of Lean Construction from the respondents' point of view (Author)

35. Are there any other barriers that you strongly believe that could affect the successful implementation of Lean Construction?

	Responses	Percent
No:	36	32.73%
Not Sure:	51	46.36%
If yes, could you please mention them?:	23	20.91%
Total Responded to this question:	110	78.57%
Total who skipped this question:	30	21.43%
Total:	140	100%

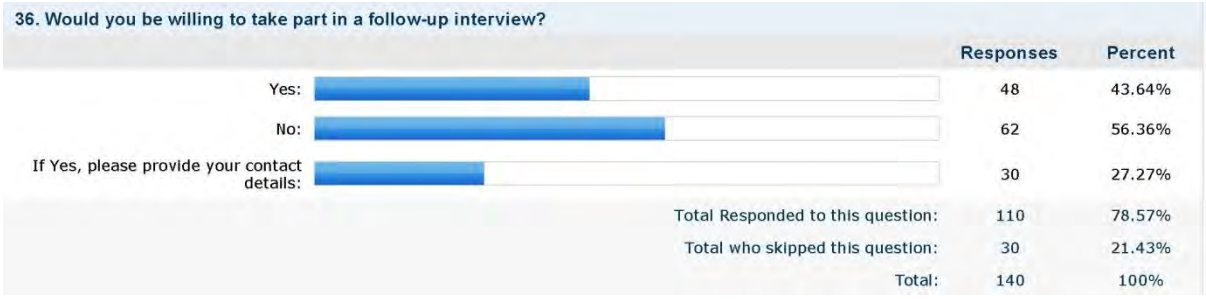
This question had a quantitative and qualitative form, and was added to help the study to identify any other possible barriers that may not have been mentioned in literature very frequently. The participants were asked if they were aware of any other possible barriers that they strongly believe could affect the successful implementation of LC. For that reason, an open text box was provided so that they could mention those barriers.

As can be seen from Table 4.32, only 23 respondents out of 110 (represent 20.91% of all respondents) stated „Yes" and mentioned their answers in the given open text box. None of the barriers mentioned by the respondents were considered as new or different barriers to those identified in question 34. For example, none of them talked about governmental barriers, corruption, political reasons, etc. Most of the barriers were the same as those in question 34 and just mentioned in a different way, while some others could be considered as sub-categories to the main barriers identified previously (i.e. many could be classified as examples to the lack of adequate lean awareness/understanding barrier). However, these invaluable answers helped the study to investigate some of the barriers in much more detail. To see the full list please refer to Appendix 12. Here are some of the barriers mentioned by the respondents:

- This is applied mainly in big organizations where there is a huge gap between top management and the operational level management. For instance, in my organization the top management has done what they think right to be lean. However, this has not been transferred to the operations/project manager(s), it is very common to hear a project manager repeating "I am a big fan of lean construction" without taking his/her statement to the commitment level;
- Old fashioned attitudes that prevent the industry from wanting to try anything new. Most people actually think things finish on time etc;
- Lack of publicity especially of success stories;
- Traditional skills-based background of construction is a major blocker;
- Client knowledge and desire;
- Top level apathy and core culture are the two main stumbling blocks;
- Lack of systems thinking;
- General conservatism and reluctance to change.

Question 36

Table 4.33: Percentage of respondents willing to take part in a follow up interview (Author)



36. Would you be willing to take part in a follow-up interview?

	Responses	Percent
Yes:	48	43.64%
No:	62	56.36%
If Yes, please provide your contact details:	30	27.27%
Total Responded to this question:	110	78.57%
Total who skipped this question:	30	21.43%
Total:	140	100%

This question was introduced to ask participants‟ for their willingness to take part in follow up interviews. As can be seen almost 44% of the respondents were willing to participate in these interviews. These interviews were mainly set up to help the author when proposing strategies for overcoming the significant barriers identified. This will be explained in more details in the following section.

4.4 Semi Structured Interviews

Based on the outcomes of the questionnaire, particularly the identification of the significant barriers to the implementation of LC, a number of semi-structured interviews were conducted, in accordance with the procedures outlined in the research methodology chapter, to help the author to investigate deeper and achieve the objective of proposing a strategy for overcoming the barriers identified. All interviews were recorded after receiving written permission from the interviewees, as it is good research practice especially in case of semi-structured interviews (Thomas *et al.*, 2005). All interviews were asked two main questions: (1) to describe the nature of each of the three significant barriers identified (e.g. how it exists and why); and (2) to propose a strategy or provide recommendations for overcoming these

barriers. A brief summary of the main outcomes of the interviews will be illustrated below. To see „full transcripts", please refer to Appendix 14.

4.4.1 Understanding the nature of the significant barriers identified

In this sub-section, a brief introduction about the background of each interviewee will be provided, and the key points of the responses to question one will be highlighted.

Interviewee number 1

This interview was conducted through internet webcam on Skype program. The interviewee is a Consultant/Author/Certified Professional Speaker in the construction industry, with more than 30 years of experience, and holding a bachelors degree in civil engineering. The following points were highlighted during the interview, as a response to question (1):

- Education (e.g. there is not enough courses within universities or colleagues teaching how lean principles could be applied in design & construction);
- Long term benefits does not interest people; as well as lack of incentives;
- Predominance of the „Make Do" type of waste in the construction industry;
- Students and recent graduates/juniors do not have adequate field experience
- Lack of sufficient project management skills;
- Mutual respect is very necessary between all the different team players in projects;
- The construction industry is still focussed on the „low-bid mentality" competition;

Interviewee number 2

This interview was also conducted through internet webcam on Skype program. The interviewee is a Productivity Manager/Lean facilitator in one of the leading contracting

companies in the UK (AAT is almost equal to £1000 Millions); with (10-20) years of practical experience and holding a masters degree. The following points were highlighted:

- The problem is that people see lean as tools rather than understanding its whole philosophy. Organisations which have taken up the complete philosophy are implementing lean more successfully than those who just focussed on the lean tools;
- Some companies say they are applying lean but they are not. This is because they do not have a lean culture/attitude within their organisation and it is not applied on a broad system-wide focus;
- People think that lean will increase the amount of labour work which is not the case. By implementing lean they will improve the efficiency and effectiveness of the production.
- Culture implementation takes a lot of time because it is a change of mind-sets, behaviours and acts that you have adopted for a long time;
- Top managers usually ask: how much money could I save? The people don‟t understand that lean is not for cost cutting. Lean will not cut your cost but yes it will save you money. There are 2 different ways of looking at things. If people say cost cuttings they will focus totally on cost cutting & ignore the main benefits. The benefits are that they will improve the workflow, productivity, the main productive hours, & eliminate waste;
- Within the UK construction industry or environment in general, there is an issue of human rights (e.g. you cannot discriminate, you do not need to restraint culture), and some people think to certain extent that lean may have a negative effect on their culture, which is not the case. Within an organisation, it will strengthen the relation between employees; and between organisations and their supply chain. However if your supply chain is not performing to your required standards you can change them. This is the message from the client now, if we as a contractor and our supply chain do not show to the clients that we are adopting a lean culture, we will not have work from them.

Interviewee number 3

This interview was conducted by telephone. The interviewee is a Quality/Business Improvements Manager in a medium construction organisation (£100-1000 Millions); has 5-10 years of experience and holding an NVQ degree. The following points were highlighted:

- Lack of basic understanding of lean concepts as well as the use of wrong methodologies;
- People just go and do tasks without planning;
- Senior managers do not explain what, why and how.
- Some people are settled of what they are doing and think that any change means adding more work;
- Lean training is considered expensive but it obtains lots of benefits. Small organisations should not worry so much about financial problems as they will need an external consultant for less time than large organisations because they have fewer employees.

Interviewee number 4

This was a face to face interview. The interviewee is an Architectural Designer (recent junior) in a small organisation (£1-10 Millions); holding a masters degree and starting recently a doctorate study. The following points were highlighted:

- Some organisations are already practicing lean and using programs that may be considered lean but they are not aware of that (e.g. BIM & 3D visual tools);
- People are comfortable with the way they used to do things (i.e. resistance to change);
- Top managers are not interested in investments which obtains benefits in the long run;
- Fear of time & commercial pressure;
- Successful lean stories are not frequently published as much as they should be.

4.4.2 Proposed ideas and strategies for overcoming the barriers identified

After discussing the nature of the barriers identified with the interviewees, they were also asked to propose a strategy or provide recommendations for overcoming these barriers (See Appendix 14). Also, a number of ideas were proposed by the author, where the interviewees were asked to show their agreement/disagreement to the ideas and provide explanations. The author‟s proposals were based on a careful and systematic analysis of the results obtained from the questionnaire. An example of this was the respondents‟ lack of awareness of the importance and advantages of supply-chain assistance which appeared through their answers of questions 30 & 31. A summary of the agreed generic strategy is provided in Table 4.34.

Table 4.34: Generic strategy for overcoming the significant barriers identified (Author)

Proposed Idea	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4
SCM	Agree	Agree	Agree	Neutral
Devising internal metrics for evaluating Performance	Agree	Agree	Agree	Agree
Gain and share benefit Schemes	Agree	Agree	Disagree	Neutral
Allocating Lean consultant/facilitator or champion of practice (CoP)	Agree	Agree	Agree	Agree
Formal Lean training/induction matrix & creating a Lean culture	Agree	Agree	Agree	Agree
Introducing Lean courses to Universities and Colleges	Agree	Agree	Agree	Agree
Publication of successful Lean case studies to educate clients	Agree	Agree	Agee	Agree
Procurement to be based on organisations‟ Lean initiatives along with their career profile, rather than the lowest price	Agree	Agree	Agree	Neutral
Government needs to establish a Lean Construction Certification Scheme (LCCS)	Agree	Agree	Agree	Neutral
Professional Institutions need to add lean principles to their objectives, by considering a specific level of lean awareness & understanding as a condition for obtaining a chartered or incorporated status	Agree	Agree	Neutral	Neutral

CHAPTER FIVE: DISCUSSION

5.1 Introduction

In this chapter, the results and findings of the collected data are discussed and examined to determine both their validity and their impact upon the aims and objectives for this study. The results of the data were illustrated in chapter 4. The questionnaire and the interviews have provided this study with data of a quantitative and qualitative nature. Therefore, the most practical way in which to dissect the data is to evaluate the results within the boundaries of the aims and objectives that this study began with.

5.2 Evaluating LC as Practiced within the Construction Industry

LC is perceived as a work approach that could improve processes and add value in the construction industry. This was also acknowledged by the Egan Committee who stated that the concepts of lean thinking would lead the UK construction industry‟s quest to improve quality and efficiency. However, there seems to be a scarce implementation of lean in the UK construction industry over the last two decades even after the publication of the Egan report (Mossman, 2009; Bashir et al., 2010). For this reason, the first objective of this study was to review LC as practiced in the UK.

By conducting an extensive literature review and referring to many case studies, a conceptual frame work for evaluating LC as practiced in the UK was adopted and modified by the author from Johansen & Walter (2007). The framework comprised of two main lean aspects: soft and hard, as shown in Figure 5.1. These two aspects incorporated nine areas which were

recognized as being fundamental attributes of a lean approach. Within each area a number of tools/techniques were identified as they were seen as being influential for improving the lean conformance of construction organisations (Appendix A). The results and the findings are discussed below.

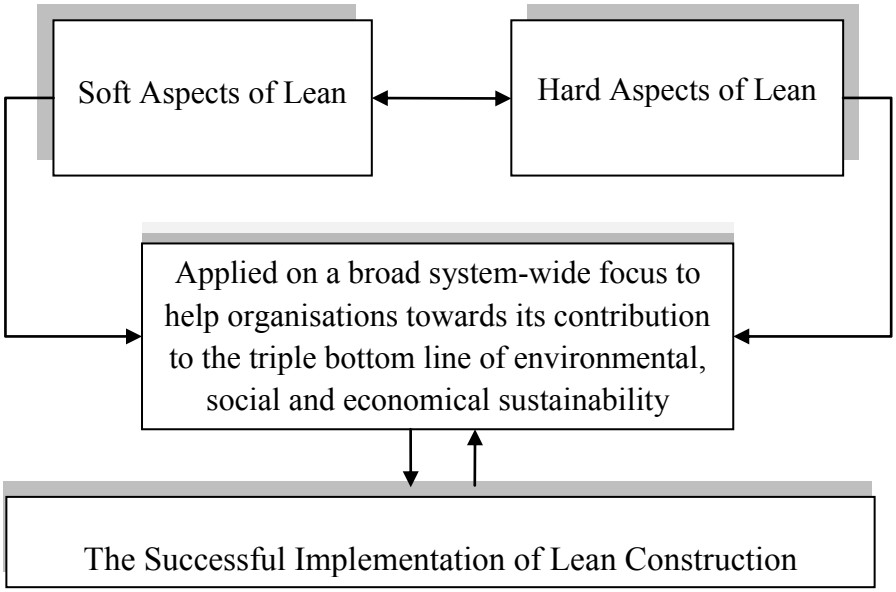


Figure 5.1: Framework for the successful implementation of LC (Author)

5.2.1 Soft aspects of lean

Lean is a philosophy first and without the philosophy tools are not nearly as effective. For this reason there were twelve areas that have been investigated by the author as the „soft aspects of lean" (Appendix A). Four out of these twelve were identified as the basic fundamental tools/techniques that could enable organisations to consider their readiness for and progress along the lean journey (Terry & Smith, 2011). Table 5.1 illustrates the results obtained from these four questions (questions 11-14).

Table 5.1: Evaluation of the readiness of construction organisations for progressing along the lean journey (Author)								
Basic fundamental soft lean tools/techniques	**Evaluation based on median values obtained**							
	1-100	**100-1000**	**1000+**	**<500 employees**	**>500 employees**	**Private organisations**	**Public organisations**	**All**
Lean capability building learning	Traditional	Learning	Leading	Traditional	Leading	Traditional	Learning	Traditional
Ability of leaders to motivate others	Leading	Leading	Leading	Leading	Leading	Leading	Leading	Leading
Lean commitment	Learning	Learning	Learning	Learning	Learning	Learning	Learning	Learning
Leadership team undertaken any formal Lean training/induction	Traditional	Learning	Learning	Traditional	Learning	Traditional	Learning	Learning
Overall evaluation based on median values	**Traditional**	**Learning**	**Learning**	**Traditional**	**Learning**	**Traditional**	**Learning**	**Learning**

As can be seen construction organisations in general were classified as „Learning" organisations. The results indicated that there is no formal lean training throughout the majority of the small organisations (in terms of size and turnover); and that any lean knowledge obtained is just by chance or through personal interest. Furthermore, although the leaders of these small organisations were classified by the respondents as being generally able to motivate others and to help teams to improve critical processes, the problem is that the majority of them are reluctant to any changes even though these changes may be able to improve the performance and increase the quality & productivity rates of their organisations. That is because the modal and median responses for question 14 in the secondary analysis illustrated that the majority of the leadership teams in small organisations are satisfied with achieving their intended objectives and that they do not need to know anything further on the LC subject (See Table 4.1 and Appendix 6). On the other side, large organisations were classified as „Learning organisations. Training is available for team leaders and project team members in the majority of these large organisations, but according to their responses the overall lean capability is patchy. The results also showed that most of the leadership teams of large organisations have some knowledge of lean which they consider to be adequate for

involvement of lean. It was also found that organisations undertaking work for public organisations were classified as „Learning" organisations; while those providing delivery services to private individuals & organisations were classified as „Traditional" organisations.

Furthermore, questions 15 and 17 were introduced to identify the extent of the application of some fundamental techniques required for a lean culture to exist within construction organisations. The results obtained from question 15 (provided in Table 5.2 below) showed that the LPDS developed by the LCI is not widely practiced amongst construction organisations. Only 19% of the respondents acknowledged that LPDS is used by their organisations to facilitate their internal and external collaborative relationships. Similarly, about 33% of the respondents went for the IPD technique. However, one area of remarkable growth is the increased amount of construction organisations that professed their engagement in long-term contractual agreements (67.27%). This will be covered under the hard aspects of lean (section 5.2.2), particularly procurement methods & contracts. On the other hand, the results suggest that large organisations are showing some promising success; as the IPD is almost used by half of these organisations and the LPDS is adopted by about 25%-29% of them. Also, around 22% of these organisations admitted that „all" the techniques provided in question 15 are used by them to facilitate internal/external relationships.

The results of question 17 (Table 5.2) showed that only a limited amount of construction organisations (17.59%) have put into practice „all" of the fundamental tasks identified to help organisations achieve the lean approach. These tasks include collaborative planning, work sequence analysis, visual management; workplace organisation, process mapping, etc. (please refer to Q17). However, it was found that medium organisations (100-1000) and large

organisations in size (more than 500 employees) are taking the lead as about 24-27% of these organisations could be considered completely ready to proceed along the lean journey

Table 5.2: Techniques/tasks practiced and set in place to help construction organisations to improve their collaborative relationships and achieve the lean approach (Author)

Fundamental soft lean techniques/tasks	Evaluation based on the frequency of use							
	1-100	100-1000	1000+	<500 employees	>500 employees	Private organisations	Public organisations	All
Long term contractual agreements	59.09%	76.67%	73.53%	56.86%	76.27%	50%	70.59%	67.27%
LPDS	9.09%	23.33%	29.41%	11.76%	25.42%	20.83%	23.53%	19.09%
IPD	18.18%	40%	47.06%	15.69%	47.46%	20.83%	23.53%	32.73%
All techniques mentioned in Q15	6.82%	23.33%	17.65%	9.8%	22.03%	4.17%	23.53%	16.36%
All tasks mentioned in Q17	11.63%	26.67%	17.65%	10.2%	23.73%	8.7%	29.41%	17.59%

Furthermore, and very interestingly, the results from Table 5.2 also illustrated that about 24% of organisations which their major client is public organisations have practical experience with „all" of the techniques given in questions 15; which suggests the establishment of excellent collaborative relations. This was emphasised by the consistency in their modal responses (LPDS, IPD, and All were selected equally). Moreover, almost 30% of these organisations have admitted that they have implemented „all" the essential lean tasks mentioned in question 17; which indicates that they are the most ready to proceed along the lean journey. On contrast, only 4% and 8.7% of the organisations which their major client is private individuals & organisations admitted that „all" of the techniques mentioned in questions 15 and 17 respectively are practiced within their organisations. It is obvious that the remarkable progress being achieved through organisations dealing with public organisations (clients) could be linked to the UK Highways Agency"s promising efforts of engaging its supply-chain in lean processes and assessing their adoption of a continuous improvement lean culture (HA, 2009a).

Questions 10 and 16 were introduced to test the respondents‟ level of awareness/understanding of the LCI-UK, and some fundamental lean concepts and practices. The results from question 10 showed that 66% of all the respondents were aware of the LCI-UK. It was found that the organisations‟ major client, size and turnover, as well as the level of education of the respondents make a little difference to the level of awareness of the LCI-UK. However, it was found that respondents with less than 10 years of experience and specifically graduates/juniors are the least aware amongst all (See Table 4.1 and Appendices 6-11). Table 5.3 demonstrates the significant variations that were found when conducting the years of experience and current role sub-classifications analysis.

Table 5.3: Level of awareness of the LCI-UK based on the experience and managerial position sub-classifications analysis (Author)

	Years of experience			Current role (Managerial level)		
	0-10	10-20	20+	Graduates/ Juniors	Middle management	Senior management
Level of awareness in percentage	47.22%	75.76%	72.72%	25%	61.29%	76.67%

Alternatively, the results of question 16 illustrated that the respondents‟ average level of awareness/understanding of some fundamental lean concepts and practices is approximately equal to 61%. The respondents were able to answer correctly eight statements out of eleven (Tables 4.12 and 4.13). It was observed from the secondary analysis that the type of the client and the level of education do not make a difference to the level of awareness/understanding of lean concepts/practices; while it was found that the organisations‟ size and turnover as well as the years of experience of practitioners only make a little difference. However, the results showed that graduates/juniors are the least aware amongst all, as they obtained much lower scores than middle and senior managers (range 42.146% - 60.7%). The graduates/juniors were only able to answer four statements correctly out of eleven; and were the only group

whose average level of awareness/understanding of lean concepts/practices was less than 50% (exactly 42.146%). Furthermore they were the only group which was not sure if the lean concept is suitable for the construction industry or not.

Several recent studies have emphasised the importance of establishing a lean culture within the construction industry (Hines *et al.*, 2011; Santorella, 2011; Terry & Smith, 2011). In earlier research by common *et al.* (2000) it was found that there was a distinct lack of understanding of the fundamental techniques for a lean culture to exist within UK construction companies; and that it appeared to be a significantly less lean culture in UK than was professed. The findings of this study are slightly different to the findings of common *et al.* (2000), but similar to the conclusions of Mossman (2009). The latter concluded that lean is happening in construction in the UK; however it is haphazard and growing slowly.

The findings of this study have shown that with the exception of graduates/juniors, the level of awareness/understanding of lean concepts and implementation techniques within construction organisations is growing gradually. It appears that construction organisations in general are currently classified as „Learning" organisations, and that medium and large organisations are not very far behind from becoming „Leading" organisations (as shown in Tables 5.1 and 5.2). About 16-18% of all the construction organisations have already set in place the basic fundamental tools/techniques that could enable them to progress successfully along the lean journey. In addition, the LPDS and IPD techniques are being used by around 19% and 33% of all the construction organisations respectively for improving their internal/external collaborative relationships. The results also suggest that the major public organisations (clients) such as the HA could play an important role in increasing the

dissemination of LC in the UK, if a lean culture is to be implemented successfully across their business and value chain.

5.2.2 Hard aspects of lean

Many researchers identified the use of inappropriate tools and approaches as a barrier to the successful implementation of LC (Johansen et al., 2002; Bashir et al., 2010) An example of this is combining traditional techniques with those that are considered lean (Common et al., 2000). For this reason, questions 18 to 28 were introduced to evaluate the level of understanding and application of LC tools/techniques within construction organisations. The evaluation of the tools/techniques mentioned or selected by the participants in the questionnaire was based on the tools/techniques identified by the conceptual framework (Appendix A), and what researchers say in literature; also by referring to the concepts of the transformation-flow-value generation (TFV) model of production which was formulated by Koskela (1992).

Procurement methods and contracts

The results obtained from question 16 (Table 5.2) illustrated that long-term contractual agreements, e.g. frameworks and partnering was selected by 67% of the respondents; and used by about 75% of the medium and large organisations. However, when referring to the answers of questions no. 31 and 32 in chapter 4, it appears that only around 20-24% of all of the respondents mentioned that economical success or environmental considerations are achieved in their organisations through supply-chain assistance. Furthermore, the results of the secondary analysis showed that only 45% of the respondents who belong to large organisations (1000+) agreed with statement no. 10 in question 16 (Table 4.1 & Appendix 6);

which states that any procurement form that tends to delegate design work to external designers, separates the design from the construction process, and thus misses the lean aim of collaboration and integration (Johansen & Walter, 2007). Based on these results, it is obvious that the advantages of the SCM are overlooked or ignored by construction organisations and that the design element of the construction process is generally delegated or contracted out; and thus the use of partnering becomes ineffective (Johansen *et al.*, 2002). According to Johansen *et al*. (2002) separating the design from the construction process fits with traditional tendering where relationships with designers tend to be filled with complexity. These results are similar to the findings of common *et al.* (2000), Johansen *et al.* (2002) and Johansen & Walter (2007).

Management concepts

According to Johansen & Walter (2007), the principles of SCM, TQM and CE are successfully applicable to the construction industry and could help organisations to achieve the LC approach. The results from question 21 in chapter 4, illustrated that 46% of the respondents acknowledged that their organisations have/had successful experience with one or more of the management concepts of TQM, SCM and CE. Most of these respondents (46% of all respondents) specified SCM and TQM, but Only 5% out of the 46% specified CE. In an earlier work in Germany by Johansen & Walter (2007), when TQM was selected by 35% of the companies and 76% of the responding companies were employing either none or just one of the listed lean management concepts, their LC management situation was considered poor. Based on that, and hence in this study 46% (nearly 50%) of the construction organisations selected both TQM and SCM, the overall situation of the construction organisations involved in this study in terms of LC management could be assessed as acceptable. However, unexpectedly, when referring to the secondary analysis (Table 4.1 and Appendices 6&7) it

was found that about 77% of the medium organisations (100-1000) and 67% of the large organisations (with more than 500 employees) have admitted that they have/had successful experience with both TQM and SCM; and thus as an exception to others, their LC management situation could be considered very good. The findings of question 21 from the secondary analysis are summarised in Table 5.4.

Table 5.4: Amount of successful experience that construction organisations have/had with the concepts of TQM and SCM (Author)

	Evaluation based on the proportion in %							
	1-100	**100-1000**	**1000+**	**<500 employees**	**>500 employees**	**Private organisations**	**Public organisations**	**All**
Amount of successful experience with TQM & SCM in %	18.6%	76.67%	56.25%	22.45%	66.67%	26%	35.29%	46.23%

Planning and control

The LPS of production control has been identified by researchers as the leading concept for combining planning and control in projects, which also introduces the next customer into the equation through continuous and collaborative planning (Johansen & Walter, 2007). The results from question 18 illustrated that the CPM which has been identified by many researches as a traditional „push-system approach" that creates waste (Howell & Ballard, 1994; Yang & Ioannou, 2001), is the most common planning technique used by construction organisations. It was also found that several organisations employ some of the LPS techniques separately such as look ahead planning, PPC tools and Constrain analysis; however these techniques are never as effective as when applied together (Johansen & Walter, 2007). On the other hand, only 19.44% of the respondents mentioned that the LPS is used by their organisations for planning and control, and in most cases it is used alongside the

CPM. These results are similar to the findings of Common *et al.* (2000) who criticized construction organisations for mixing lean tools such as the LPS with traditional planning tools such as the CPM.

However it was observed through data collection, particularly from interviewee number two who is a senior manager in one of the leading contracting companies in the UK, that the CPM is only used for the high level master plan and for testing the feasibility of bids/offers at the tender stage. They began to see software programmes such as Primavera and MS project as a tool, but LPS as a philosophy and a planning technique. Therefore, this could be considered as a good starting point. The author suggests that by the time as construction organisations develop their learning and understanding to lean concepts and implementation techniques, they will have no need to have two planning systems on the go anymore.

Design

The participants were asked in question 23 about the tools/techniques used by their construction organisations to simulate flow by enhancing coordination and information procedures. A number of lean tools were introduced such as BIM, VDS, VR tools and DSM. Very interestingly, only 24.76% of all respondents mentioned that none of these techniques are used at all. Around 14% mentioned that DSM and VR tools are used by their organisations, and about 8% went for VDS. However, surprisingly, BIM came first as it was selected by 35% of the respondents. This increased awareness of the use of BIM could possibly be linked to the UK Government‟s decision to push forward with BIM, where the use of BIM will be mandatory within 5 years with all government projects. These results are better than those obtained from an earlier study in Germany by Johansen & Walter (2007); and it indicates that there is a high potential for improving the design process in the UK

construction industry. However, some argue that although BIM could help to improve information flow and reduce design error; but without lean and without cultural reform in the industry it could fail to deliver the benefits anticipated, and may be just treated as a 3D tool rather than a collaborative modelling technique (Love *et al*., 2011).

On the other hand, question 24 was introduced to identify the tools/techniques used by organisations to prevent value loss by reducing inconsistent decision making. Only about 20% of the respondents mentioned that the concept of concurrent design of the product and the process is used within their organisations, and 15% for set based design. These results are similar to the findings of Johansen & Walter (2007), and indicate that there is a general lack of understanding of the principles of integrating design and construction within construction organisations.

Installation of design (Lean assembly process on site)

The results of question 19 showed that the majority of the respondents were not familiar with the techniques used for minimising uncertainty in production processes. The highest proportion of the respondents (43.5%) mentioned that none is used; while about 39% mentioned PDCA techniques, 20% stated pre-fabrication strategies, and only 12% went for first-run studies. The participants were then asked in question 20 about the techniques used by their organisations for planning and organising the movement of crews and materials as well as the production processes itself. The results indicated that important techniques such as visual management and CFP are not widely used. Also, only about 18% of the respondents selected the LPS for production control. In addition, when the respondents were asked once again in question 25 about the areas of application of LPS within construction organisations, planning as an activity scheduling tool came first; which means that the respondents are not

aware of the full benefits of LPS. However, when referring to the secondary analysis (Table 4.1 and Appendix 6), it was found that almost 28% of the large organisations use LPS as a productivity control technique but this amount decreases significantly as the turnover of organisation decreases. Furthermore, when respondents were asked in question 26 about their understanding of the function of the PPC value within the LPS, only 15.38% of all respondents were able to answer the question correctly and realise that the PPC value does not measure the level of utilization of a work flow (efficiency); as it measures production planning effectiveness and workflow reliability instead (Forbes & Ahmed, 2011). These inconsistencies in the answers of the respondents regarding the use of the LPS for production control could be an indication of the lack of adequate awareness/understanding of the application of lean tools/techniques within construction organisations. These results are consistent with the findings of common *et al.* (2000).

Supply

The participants were asked in question 22 to identify the techniques used by their suppliers for the provision of materials to construction sites. A number of typical lean supply techniques were provided such as JIT, value stream analysis and Kanban were provided. The results showed that that there is a lack of awareness of the supply principles, as the highest proportion of the respondents mentioned that they do not know (34% of the respondents). JIT which has been well known to several production industries for decades was selected by just 30% of the respondents, and the value stream analysis and Kanban techniques were hardly selected. Also some of the respondents who went for the „other" option mentioned that materials are ordered to their sites in accordance with their project team's programmes but without an existence of a formal policy. By linking these results to the results of question 31 and 32 where it was shown that SCM advantages are not well considered by construction

organisations, it could be concluded that most of the construction organisations lack a comprehensive lean approach to supply. These findings are very similar to the findings of Johansen & Walter (2007).

Performance measurement

The selection of appropriate measures has a major influence on the implementation of strategies, and is essential for the continuous development of improvement programmes (Lantelme & Formoso, 2000). That is because without the use of appropriate PMSs, it becomes very difficult for organizations to understand why poor performance continues. Based on a comprehensive literature review (section 2.5), a number of process-oriented (leading) measures were selected and provided alongside other traditional (lagging) measures through question 27; to determine the techniques used by construction organisations for performance measurement. The results revealed that results oriented KPIs are the most common technique used amongst construction organisations for performance measurement (selected by almost 75% of the respondents). It was also found that many organisations still rely on the experience of their managers as a means for performance measurement. These two approaches are no longer appropriate for continuous improvement, and have been criticised by many researchers (Alarcón et al., 2001; Mitropoulos & Howell, 2001; Takim & Akintoye, 2002; Costa et al., 2004; Moon et al., 2007).

Despite the fact that continuous improvement requires analysis of processes and devising an internal metrics for evaluating performance, only about 35% of the respondents mentioned that their organisations use their own metrics that is consistent with their business strategy. Also, process performance measures which are the type of measurement recommended for the successful implementation of LC was selected by just 27% of all respondents. However,

in question 28, when the respondents were asked to give a score out of ten (10 being the most important and 1 being the least important) to some non-financial performance measures, the mean values of three measures namely: safety, client satisfaction and quality obtained a score above 8 (most significant); and the lowest score obtained amongst all other performance measures was 7.6. These results indicated that although the respondents recognise the importance of performance measures, it has not been properly and widely implemented in the construction industry. Most managers still make decisions just based on their experience & common sense, and on a few traditional financial measures which are no longer suitable in the existing competitive environment.

Furthermore, when the respondents were asked in question 16 to indicate their level of agreement to statement 5, most of the respondents agreed that using performance measurement for self defence or evidence of claims and counter claims is recommended. This contradicts the LC theoretical framework, where PMSs should be strongly related to „decentralised control" and used for continuous improvement and in the learning process at operational level; instead of being used for looking for who or what is to blame when problems occur (Lantelme & Formoso, 2000). These results suggest that there is a considerable lack of awareness of the application of performance measurement and its role, in terms of providing process transparency and creating conditions for decentralised control to be implemented. Although the data obtained from this question were evaluated and indicated a high degree of reliability, further research would be recommended to confirm its validity.

5.2.3 Benefits and holistic view of lean construction

Evidence of the use of lean thinking has shown that there are benefits to be gained from applying lean principles to construction (Ansell *et al.*, 2007). Based on a comprehensive

literature review to understand the possible benefits that could be made from the successful implementation of LC (section 2.1), a list of benefits were identified and introduced though question 29 where the respondents were required to specify the top five benefits only. The results are shown in Figure 5.2.

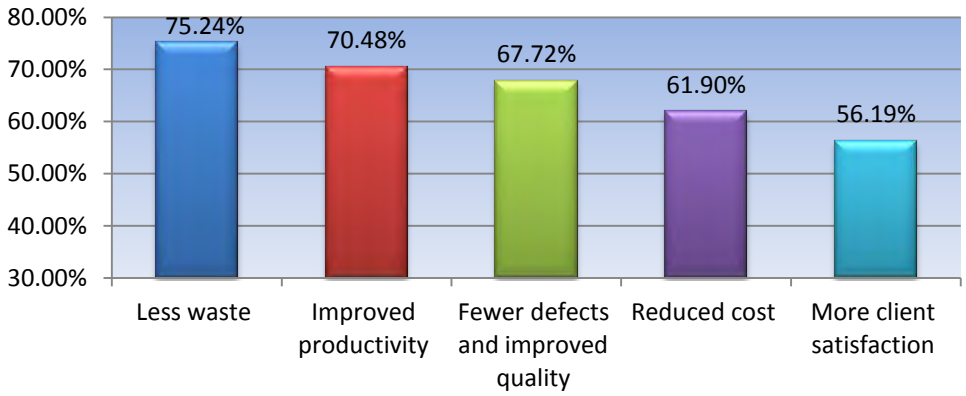


Figure 5.2: Top 5 benefits of LC according to the respondents' perspectives (Author)

From the secondary analysis, it was found that all sub-classifications agree on these top 5 but in different orders. However, it appeared that large organisations in terms of size and turnover were the only group amongst all which were aware of the improved safety and health conditions that could be achieved from the implementation of LC principles and activities (Table 4.1 and Appendices 6-11). Also, very interestingly some of the respondents who selected the „other" option added comments like why restrict to five. Hence, all of the top 5 benefits were selected by more than half of the respondents; this suggests that the respondents are relatively aware of the benefits of lean.

Then, in question 33, when the respondents were asked again to specify the reasons that pulled/could pull their organisations to go on the lean journey, the results showed that the top three reasons are improving rate of client satisfaction, increasing profit/turnover and improving quality of outputs respectively. By linking this result with the results of question

28 where client satisfaction was identified as one of the significant non-financial measures according to the respondents‟ viewpoint, it is very clear that the respondents are customer focussed. This is a promising improvement; however construction organisations still need to draw their attentions on how customer value could best be achieved, especially when the results of questions 22, 31 and 32 have shown a lack of awareness of the importance of fundamental approaches like SCM and value stream mapping and analysis.

On the other hand, the results of questions 31-33 revealed that the majority of the construction organisations do not yet have a holistic view of the full potentials of lean; and that LC is hardly implemented on a broad system-wide focus to help organisations towards its contribution to the triple bottom line of environmental, social and economical sustainability.

5.3 Barriers to the Successful Implementation of LC

An extensive literature review was conducted to understand the possible barriers to the successful implementation of LC in the UK (section 2.4). Based on a thorough analysis of these barriers, they were merged and classified by the author into 10 different categories. Consequently, questions number 34 and 35 were introduced:

1) To see if the real world agrees with the author‟s identification of the key barriers to the successful implementation of LC;
2) To identify the most significant barriers according to its influence on the implementation of LC, based on the mean values obtained;
3) To prioritise the barriers identified and evaluate its effect on the successful implementation of LC.

5.3.1 Checking the participant's agreement to the key barriers identified

From the analysis of the results shown in Table 4.30, the output that was discovered is illustrated in Table 5.5 below.

Table 5.5: Influence of the barriers identified on the successful implementation of Lean Construction (Author)

No.	List of the key barriers identified	Answer Scale* (5= Strongly Agree and 1= Strongly Disagree)					Frequency Score Total	
		5	4	3	2	1	Strong Influence (4 + 5)	Weak Influence (1 +2 +3)
B1	Fragmentation & subcontracting	26	49	23	10	1	75 (68.8%)	4 (31.2%)
B2	Procurement & contracts	22	47	30	10	0	69 (63.3%)	40 (36.7%)
B3	Lack of adequate Lean awareness & understanding	50	48	11	1	1	98 (88.28%)	13 (11.72%)
B4	Culture & human attitudinal issues	35	54	15	6	1	89 (80.18%)	22 (19.82%)
B5	Time & commercial pressure	29	51	19	9	2	80 (72.72%)	30 (27.28%)
B6	Financial issues	17	43	29	20	2	60 (54.05%)	51 (45.95%)
B7	Lack of top management commitment	42	44	16	8	1	86 (77.48%)	25 (22.52%)
B8	Design/Construction dichotomy	20	34	30	18	5	54 (50.47%)	53 (49.53%)
B9	Educational issues	18	52	23	13	3	70 (64.22%)	39 (35.78%)
B10	Lack of process based PMSs	16	49	30	12	3	65 (59.1%)	45 (40.9%)

*Scale 3 is considered neutral and is categorised within the non-influencing group.

These findings of the analysis as shown in Table 5.1, demonstrate that all the key barriers identified by the author were recorded by responses in terms of influence with more than 50

percent frequency. This clearly proves that the majority of the respondents agreed with the author"s identification of the key barriers to the successful implementation of LC. Hence the measurement of reliability is essential to the validity of the results (Lam *et al.*, 2007); the data received for this question were entered into SPSS 19.0 software to evaluate its reliability using Cronbach"s Alpha coefficients. The coefficient obtained a value of 0.747 which indicates the „"reliability"" of the results as it greater than the acceptable threshold (0.7) (Lam *et al.*, 2007; Ab Rahman *et al.*, 2011).

The validity of the results obtained from this question can be assessed against other studies. In similar research, the same approach used by the author for reaching these findings was conducted by Abdullah *et al* (2009). Furthermore, in earlier studies, Mossman (2009) and Bashir *et al.* (2010) investigated all of the barriers identified by the author except B8 & B10.

5.3.2 Identifying the most significant barriers to the successful implementation of LC

With the same data obtained in Table 5.5, further analysis was conducted using the mean values of each barrier (as shown in Table 5.6 below). It was found that only three barriers obtained a mean score above four, namely, lack of adequate lean awareness/understanding, lack of top management commitment, and culture & human attitudinal issues. In several studies, the level of significance was represented by a score of „"4"" on a five-point Likert scale (Chan, 2003; Abdullah et al., 2009). This seems to be a common threshold in most construction research (Lam et al., 2007). Within this context, these three barriers (B3, B4 and B7) were classified as the significant barriers to the successful implementation of LC.

These results obtained are consistent with the findings of studies conducted by Common *et al.* (2000) and Johansen & Porter (2003). These two studies revealed that there is a considerable lack of understanding to the fundamental concepts and application of lean within UK construction companies; and that there are also some structural and cultural barriers identified that need to be addressed before the LC concept can be fully successful in the UK. In other studies conducted in different countries, it was found that lack of attentiveness & commitment from top management and difficulties in understanding the concept were the main factors hindering the implementation of the LC concept in their construction industries (Abdullah *et al.*, 2009; Alinaitwe, 2009).

Table 5.6: The significant barriers to the successful implementation of LC (Author)

ID	The barriers identified	Mean	Standard deviation
B1	Fragmentation & subcontracting	3.7658	0.99959
B2	Procurement & contracts	3.6937	0.95148
B3	Lack of adequate Lean awareness & understanding	4.3063	0.76030
B4	Culture & human attitudinal issues	4.0450	0.86747
B5	Time & commercial pressure	3.8919	0.97562
B6	Financial issues	3.4775	1.01665
B7	Lack of top management commitment	4.0631	0.94657
B8	Design/Construction dichotomy	3.3423	1.18702
B9	Educational issues	3.5856	1.03983
B10	Lack of process based PMS	3.5495	0.98847

Note: The shaded areas represent the significant barriers identified

5.3.3 Prioritising the barriers identified with the aim of evaluating their effect on the successful implementation of LC

Based on the participants‟ perspectives on the influence of the barriers identified on the successful implementation of LC, and by referring to the mean analysis findings (shown in Table 5.6) the barriers were ranked and illustrated as shown in Figure 5.3.

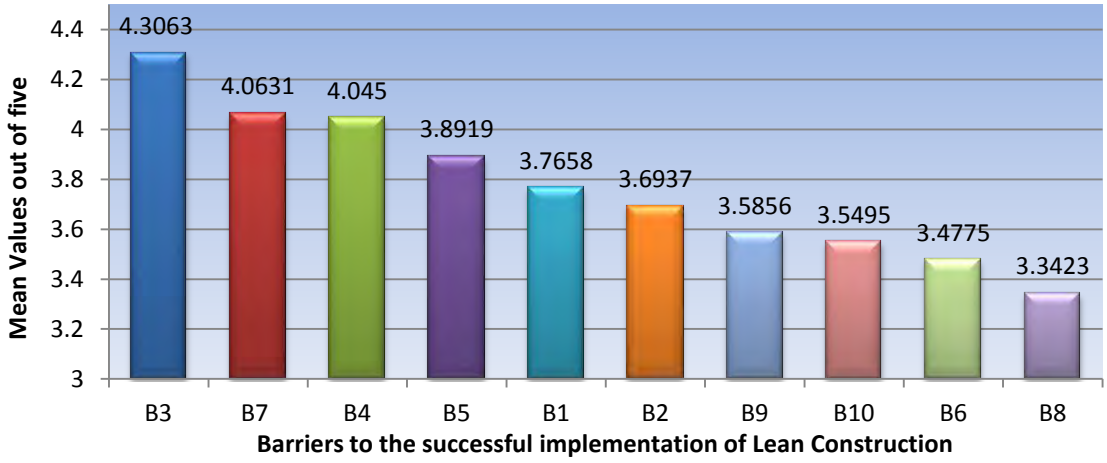


Figure 5.3: The Prioritisation of the barriers identified according to their effect on the successful implementation of LC (Author)

As can be seen, it appears very clearly that financial issues (B6) were not considered by the respondents as a main threat to the implementation of LC, seeing that they ranked it very low (9th out of 10). Another significant observation is that, by referring to the overall secondary analysis, it appears without a doubt that the lack of adequate lean awareness/understanding (B3) is considered the most significant barrier to the implementation of LC; as it was ranked by all sub-classifications as their number one. The author suggests that this common agreement on the fact that the lack of adequate lean awareness/understanding is the most significant barrier to the implementation of LC could be seen positively; as it indicates that the professionals in the construction industry have the ability of self-criticism which is

identified by Johansen & Walter (2007) as one of the fundamental behavioural aspects of lean construction.

The methodology adopted for prioritising the barriers and carrying out this evaluation is comparable to the approaches conducted by similar studies (Abdul-Hadi *et al.*, 2005; Alinaitwe, 2009). Therefore, this evaluation (based on the priority list) could be used to help the construction industry to focus its attention and resources on the key issues.

5.4 A Strategy for Overcoming the Significant Barriers Identified

Having identified the significant barriers to the successful implementation of LC based on the respondents‟ perspectives, a number of semi-structured interviews were conducted (section 4.4 and Appendix 14). These interviews were essential in order to help the author to investigate deeper, have a better understanding of the nature of each of the barriers identified, and discuss solutions & proposals to overcome these barriers. Although about 40% of the respondents of the survey agreed to take part in the follow-up interview (Q36), only 4 professionals were selected. During the selection process, the author focussed on ensuring the diversity of the participants, so that they can represent all the 6 different classifications adopted for the secondary analysis.

Through these informative discussions with the interviewees, a number of proposals & ideas were determined. Only those proposals which were agreed up on by the majority of the interviewees were taken forward to form the structure of a generic strategy for overcoming the significant barriers identified (Table 4.34). Then, by referring to the overall results of the survey, four distinct categories of response were distinguished. From a strategy perspective there were those involved in the private sector, those involved in the public sector, and the

survey seems to have identified different needs associated with each sector. It appeared to the author, from the findings of the secondary analysis, that there were two clear levels of need. A basic level for those confronted by barriers (i.e. recent graduates/junior staff), and an advanced level for those capable of removing barriers (i.e. senior and experienced managers). Finally, by analysing the generic strategy within the context of the four categories described above, a final strategy was adopted (Table 5.7).

Table 5.7: A proposed strategy for overcoming barriers to the successful implementation of LC (Author)

PUBLIC ORGANISATIONS (Governmental) • Implementing a Lean culture across the whole business and value chain • Procurement to be based on organisations‟ Lean initiatives along with their career profile, rather than the lowest price • Establishing a Lean Construction Certification Scheme (LCCS) • Supply-Chain Management • Allocating champions of practice to provide learning opportunities to all of its members and prepare project teams for challenges they may face	**PRIVATE ORGANISATIONS** • Providing a formal Lean training/induction matrix • Hiring external Lean consultants • Devising internal metrics of leading parameters for evaluating performance and organisational learning • Increasing the Lean awareness/knowledge of clients through the publishing of successful Lean case studies • Creating a „Gain and Share‟ benefit Scheme, where bonuses & incentives are based on the profitability of the production rather than the productivity rates
GRADUATES • Lean principles to be added to the curriculum at Universities and Colleges • Companies and organisations to provide Lean induction sessions to all recent graduates & juniors	**SENIOR MANAGERS** • Professional institutions should only award chartered/ incorporated status to professionals and managers who could demonstrate at least a basic level of awareness and understanding of Lean

CHAPTER SIX - CONCLUSIONS AND REFLECTIONS

6.1 Lean Construction, as Practiced in the UK

The first aim of this study was to evaluate LC, as practiced in the UK. Based on a comprehensive literature review, a theoretical framework was adopted and modified by the author; and it formed the basis for the questionnaire survey. The responses of the questionnaire were then subject to a secondary analysis, as well as a quantitative and qualitative analysis in pursuit of the objectives of the study.

The study revealed that although the level of awareness of the lean principles amongst construction organisations is growing gradually, there is still a significant lack of understanding of how to successfully apply these lean principles to construction processes and activities.

Hence this study received 140 responses where more than half (63%) of the respondents were from practitioners with more than 10 years of experience holding senior positions at the directional and managerial level in their respective, and due to the diversity of the respondents as well as the very well distributed mixture of organisations involved in the study, the author considers the sample to be representative of the UK construction industry as a whole; and also believes that the findings of this study have validity throughout the whole UK construction industry. The main findings of this study are illustrated, as follows:

- Recent graduates/juniors have a significant lack of awareness/understanding of Lean principles, practices, and even the LCI-UK;
- Lean concepts are hardly implemented among construction organisation on a broad system-wide focus;

- Large and medium organisations in terms of size & turnover, particularly those dealing with public organisations, are the most ready to proceed along the lean journey.
- Any Lean knowledge throughout most of the construction organisations is just obtained by chance and through personal interest;
- Long term contractual agreements & document management systems are the most common techniques used by construction organisations for facilitating external and internal collaborative relationships;
- The critical path method is the most common technique used by construction organisations for planning & control;
- A large amount of construction organisations do not practice any lean techniques for minimising uncertainty in production processes;
- The LPS and visual management techniques are not practiced by most of the construction organisations;
- Most of the construction organisations lack a comprehensive lean approach to supply;
- The level of awareness of the use of BIM amongst professionals is increasing; but the state of the construction organisations in terms of facilitating the integration of design and construction by means of contracts and design procedures appears to be at a rather early stage of lean construction development.
- Most of the construction organisations do not practice any lean techniques to prevent value loss by reducing inconsistent decision making. Concurrent engineering and set-based design strategies are hardly practiced;
- LPS is mostly used as an activity scheduling tool within construction organisations;
- Results oriented KPIs and the experience of managers are the most common techniques used by construction organisations for performance measurement;

- The top three non-financial parameters according to their importance to construction organisations are: 1- Safety, 2- Customer/client satisfaction, and 3- Quality;
- The top 5 benefits perceived benefits of applying Lean thinking to construction according to the respondents‟ perspectives are: 1- less waste, 2- improved productivity, 3- fewer defects and improved quality, 4- reduced cost, and 5- increased client satisfaction;
- Cost & value management and risk management & mitigation are the most common techniques adopted by construction organisations to achieve economic success;
- International standards & accreditation (e.g. ISO 14001) are the most common techniques used by large organisation, but BREAM is the most frequently used by small ones;
- In-house training and community engagement are the most two common approaches used by construction organisations for achieving social benefits to their employees;
- The top three reasons that could pull construction organisations to go on the lean journey are: 1- improving rate of client satisfaction, 2- increasing profit/turnover and 3- improving quality of outputs.

6.2. Barriers to the Successful Implementation of LC in the UK

An extensive literature review was conducted to understand the possible barriers to the successful implementation of LC in the UK. Based on a thorough analysis of these barriers, they were merged and classified by the author into 10 different categories. The findings of this study has shown that only three out of these ten were considered as significant barriers to the successful implementation of LC in the UK (Table 6.1), namely, lack of adequate lean awareness & understanding, lack of top management commitment, and Cultural & human attitudinal issues. The barriers were then prioritised with the aim of evaluating their effect on the successful implementation of LC, as shown in Figure 6.1 below.

Table 6.1: The significant barriers to the successful implementation of LC in the UK (Author)			
ID	**The barriers identified**	**Mean**	**Standard deviation**
B1	Fragmentation & subcontracting	3.7658	0.99959
B2	Procurement & contracts	3.6937	0.95148
B3	Lack of adequate Lean awareness & understanding	4.3063	0.76030
B4	Culture & human attitudinal issues	4.0450	0.86747
B5	Time & commercial pressure	3.8919	0.97562
B6	Financial issues	3.4775	1.01665
B7	Lack of top management commitment	4.0631	0.94657
B8	Design/Construction dichotomy	3.3423	1.18702
B9	Educational issues	3.5856	1.03983
B10	Lack of process based PMS	3.5495	0.98847

Note: The shaded areas represent the significant barriers identified

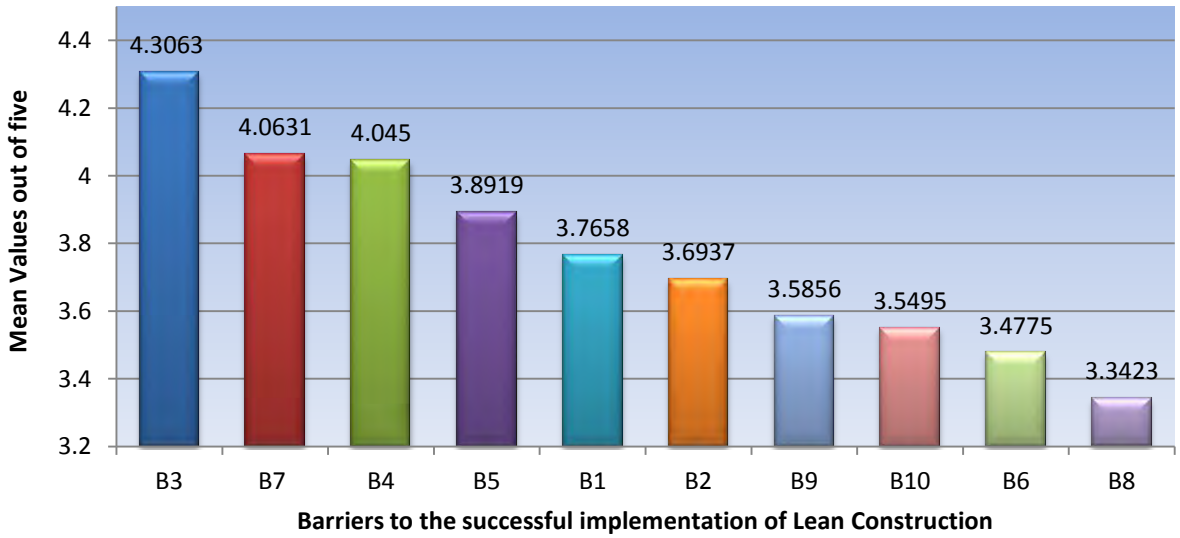


Figure 6.1: The Prioritisation of barriers according to their effect on the successful implementation of LC in the UK (Author)

6.3 A Proposed Strategy for Overcoming Barriers to the Successful Implementation of LC in the UK

Through an in depth analysis of all the data collected from the questionnaire and the conducted interviews, the following strategy was proposed to overcome the significant barriers identified (Table 6.2).

Table 6.2: A proposed strategy for overcoming barriers to the successful implementation of LC in the UK (Author)

PUBLIC ORGANISATIONS (Governmental) • Implementing a Lean culture across the whole business and value chain • Procurement to be based on organisations‟ Lean initiatives along with their career profile, rather than the lowest price • Establishing a Lean Construction Certification Scheme (LCCS) • Supply-Chain Management • Allocating champions of practice to provide learning opportunities to all of its members and prepare project teams for challenges they may face	**PRIVATE ORGANISATIONS** • Providing a formal Lean training/induction matrix • Hiring external Lean consultants • Devising internal metrics of leading parameters for evaluating performance and organisational learning • Increasing the Lean awareness/knowledge of clients through the publishing of successful Lean case studies • Creating a „Gain and Share‟ benefit Scheme, where bonuses & incentives are based on the profitability of the production rather than the productivity rates
GRADUATES • Lean principles to be added to the curriculum at Universities and Colleges • Companies and organisations to provide Lean induction sessions to all recent graduates	**SENIOR MANAGERS** • Professional institutions should only award chartered/ incorporated status to professionals and managers who could demonstrate at least a basic level of awareness and understanding of lean

6.4 Recommendations

Below are the author‟s recommendations for further studies:

- Implementing the proposed strategy and evaluating its effectiveness;
- Using the modified conceptual framework for future research, as it has a balance between the soft and hard aspects of lean;
- Using the same questionnaire for conducting similar studies in different countries. By comparing the results obtained from different countries, it could be a good practice of international benchmarking; as it would help to identify the strengths and weaknesses of different construction organisations;
- Referring to the secondary analysis, which consisted of six different classifications, and carrying out further investigation is strongly recommended. Each classification could be treated as a specific case study;
- It appeared from the qualification sub-classification analysis, that respondents holding NVQ and HND qualifications provided the most optimistic and consistent answers which sometimes declined significantly as the level of education increased. Further investigation is highly recommended;
- Adding one question to the questionnaire to differentiate between respondents working on and off site could be useful; because it would help to categorise respondents who selected a non-applicable answer;
- Carrying out more interviews, particularly face to face ones;
- From the analysis of the data collected, the author suggests that the adherence of professionals to substance thinking acts a hidden barrier to achieving progress in the construction industry. An example of this from the findings of the survey was the over

reliance of the respondents on using results based KPIs (object metaphysics) for performance measurement, as opposed to process performance measures (flow metaphysics). However, further investigation is required to confirm the validity of this suggestion.

- Referring to the full transcripts of the interviews is extremely important. One of the interviewees had a concern about the HALMAT; as it is mainly based on a qualitative analysis rather than a quantitative one. When it comes to measuring a culture, it is difficult to bring it into numbers (quantify it). Thus, this issue needs to be carefully addressed. One proposed solution is that companies may have to show, from their previous projects, what sort of cost benefits they have saved and how they achieved that.

6.5 Limitations of the Study

- There are some other areas related to the soft aspects of lean, present in Terry & Smith (2011), which the author could not cover in his study due to time constraints and the size of the questionnaire. These areas include: understanding key processes, benefits tracking & management, role of champions, etc.
- Time limitations- the author did not have a chance to discuss and demonstrate many other findings from the secondary analysis due to time constraints; however investigating the secondary analysis is highly recommended for future studies, as mentioned previously. Also, only a limited amount of interviews were conducted, when compared to the size of the sample, due to time limitations;
- Cost limitations- the author was not able to carry out many face to face interviews, due to the expenses of travelling.

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APPENDIX 1: DEVELOPMENT OF THE MODIFIED CONCEPTUAL FRAMEWORK

Conceptual Framework

In their work Common *et al* (2000) and Johansen *et al.* (2002) identified four areas as being fundamental attributes of a Lean approach, namely Procurement, Planning, Control and Management (Figure A1.1).

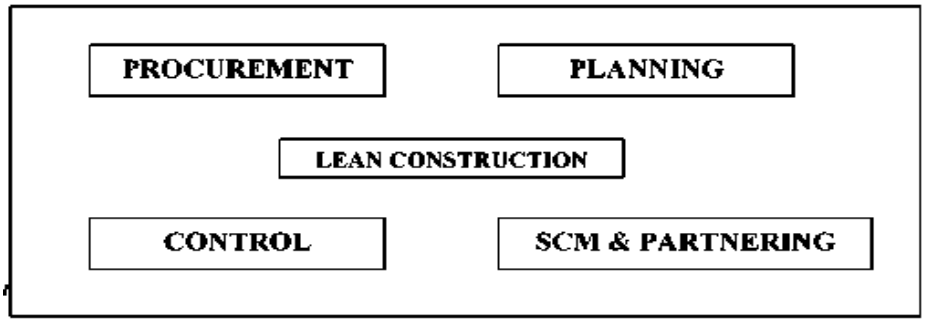


Figure A1.1: Conceptual Framework (Common *et al.*, 2000; Johansen *et al.*, 2002)

Within each area they recognised a number of techniques that were seen as being instrumental for the realisation of lean construction. The techniques documented included Design & Build, Lookahead Planning, Last Planner, Supply Chain Management and Partnering.

However, this framework was considered to be no longer sufficient due to the progress made since the studies by Common *et al* (2000) and Johansen *et al.* (2002) were carried out. Taking into consideration the developments in lean construction, Johansen & Walter (2007), developed the conceptual framework to include eight areas (Figure A1.2).

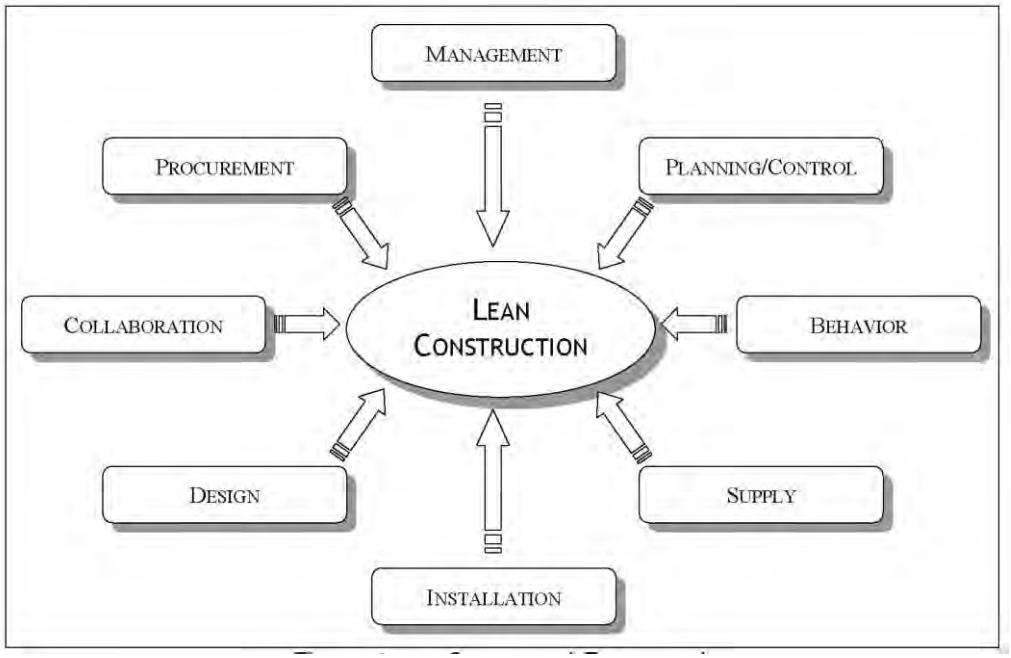


Figure A1.2: Updated Conceptual Framework (Johansen & Walter, 2007)

However, there have been vast developments made among the lean construction community since the study by Johansen & Walter (2007) was carried out. Several recent studies have emphasised the importance of establishing a lean culture among the construction industry (Hines et al., 2011; Santorella, 2011; Terry & Smith, 2011). There has also been an improved understanding of the importance of using appropriate performance measurement systems (PMS) to support the successful implementation of LC (section 2.5). As a result lean construction implementation efforts have become more comprehensive.

Taking into consideration the progress of development in lean construction to date, the framework established by Johansen & Walter (2007) was modified by the author to include two main lean aspects: soft and hard, as shown in Figure A1.3 below.

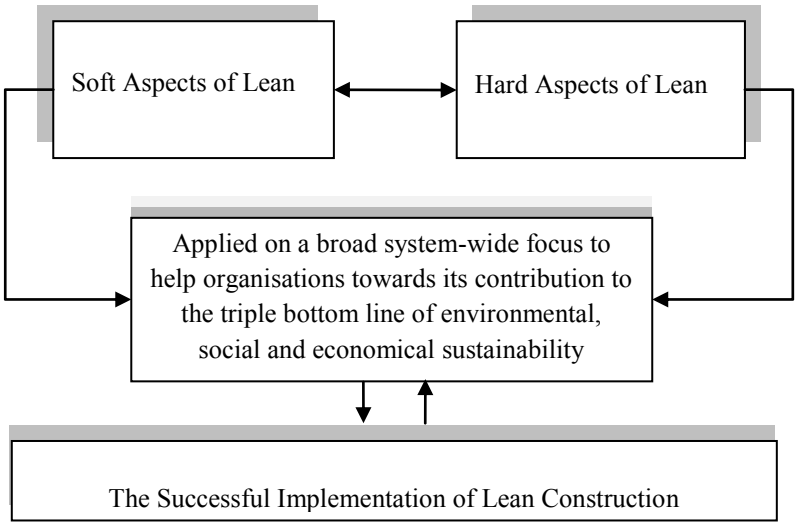


Figure A1.3: Modified Conceptual Framework (Author)

These two aspects incorporated nine areas which were recognized as being fundamental attributes of a lean approach. Within each area a number of tools/techniques were identified as they were seen as being influential for improving the lean conformance of construction organisations (Table A1.1).

Table A1.1: Fundamental attributes of a lean approach, adopted and modified by author from Johansen & Walter (2007)

Focus Areas	**Lean Conformance**
I. Soft Aspects of Lean	
1. Lean culture	There are eleven areas that have been identified as fundamental tools and aspects that enable organisations to consider their readiness for and progress along the lean journey (Terry & Smith, 2011): (1) lean awareness and understanding, (2) the ability to motivate others, (3) lean commitment, (4) lean capability building, (5) work sequence analysis, (6) data analysis, (7) visual management, (8) workplace-organisation, (9) standardising work, (10) process mapping, and (11) problem solving

2. Developing internal/external collaborative relationships	*Techniques and tools to facilitate the collaboration aspect of LC*. These include: long term contractual agreements (e.g. partnering & frameworks), Cross functional teams, Document Management Systems, Project Information Systems, and collaborative planning schedules
II. Hard Aspects of Lean	
3. Procurement methods	*Integrated procurement strategies* such as: Design and Build, Management Contracting, and Partnering.
4. Management concepts	*Principles of Supply Chain Management, Concurrent Engineering, Total Quality Management; Value Management, Waste Management and Change Management.*
5. Planning and control	*These are techniques and tools that aim for the reduction of flow variability and uncertainty*. *Management Control with Last Planner System of Production Control has been identified as the leading concept*. That is because it incorporates all of the following techniques: Last Planner as an Activity Tool; Percentage Complete Planning Tools, Work-Flow Production Management as a Construction Scheduling Tool; Look A-head Planning; Reverse Phase Scheduling, Constraint Analysis, Buffering Analysis, and Weekly Work Planning
6. Construction design	*Techniques that prevent value loss by reducing inconsistent decision making*, e.g. Concurrent Design of the product and the process, Set-based Design Strategy; *Techniques that simulate flow by enhancing coordination and information procedures*, e.g. Design Structure Matrix, Virtual Design Studios, and Virtual Reality Tools; *Waste minimisation through design* (Including waste as a formal agenda item at design team meetings).
7. Installation	*Techniques for planning and organising the movement of work crews and materials as well as the production processes itself*, e.g. Continuous flow processing (CFP), Visual Management , LPS; the use of transportation support system integrating horizontal and vertical movements (e.g. Crane)

	Techniques for minimising uncertainty in production processes, e.g. First Run Studies, (PDCA), Pre-fabrication strategies; *The Utilisation of a site logistic tool*, e.g. the 5S-Method.
8. Supply	*The provision of materials to the construction site at the appropriate time, of the desired quality and to the right amount.* Tools and techniques include: JIT, Kanban System, Value Stream Analysis, and ISO9001.
9. Performance measurement & evaluation	*Techniques for Continuous Improvement & Organisational Learning*. Tools and techniques include: process performance measures, benchmarking, LPS, Leading indicators, Balanced Scorecards, QMPMS, DQIs, 5 Whys Method for rework executed, First Run Studies, PDCA and Daily/Weekly Hurdle Meetings.

Note: The shaded areas represent the areas modified by the author.

APPENDIX 2: APPROACHES USED FOR CONDUCTING RESEARCH

A2.1 Research Approaches

Research methods in education and other social sciences are often divided into two main types: quantitative and qualitative methods (Muijs, 2004). In the former numbers are used to describe the outcomes and in the latter words are used instead (Berry, 2005). For many years, research in disciplines which lie between natural sciences and social sciences, particularly management of technology and engineering, has been drawn towards the adoption of quantitative scientific methods (Fellows & Liu, 2008). However, in recent years, the recognition of the value and appropriateness of qualitative methods has increased (Bryman, 2004; Berry, 2005). These qualitative studies facilitate the appreciation and understanding of basic causes and principles, specifically behaviour (Fellows & Liu, 2008). However, each of these two approaches has its own set of advantages and disadvantages. A comparison of these research methods is illustrated in Table A2.1 below.

Table A2.1: Contrasting characteristics of qualitative and quantitative research (Kanbur, 2003; Thomas *et al.*, 2005)

Research Component	**Quantitative**	**Qualitative**
Outcome information	Numerical	Non-numerical
Hypothesis	Deductive	Inductive
Sample	General, random, large	Specific, purposive, small
Setting	Laboratory	Natural, real world
Data gathering	Objective instrumentation	Researcher is primary instrument
Design	Determined in advance	Flexible, may change
Data analysis	Statistical method	Descriptive, interpretive
Disciplinary framework	Neo-classical economics (and natural sciences)	Broad social sciences

A2.2 Mixed Approaches

The term ‘mixed methods’ refers to a research strategy that crosses the boundaries of conventional paradigms of research, by intentionally combining methods drawn from different traditions with different underlying assumptions(Denscombe, 2007). At its simplest form, a mixed methods strategy is one that combines both quantitative and qualitative methods (Greene *et al.*, 1989; Bryman, 2001; Creswell, 2003; Bryman, 2006; Denscombe, 2007).

According to Denscombe (2007) the mixed methods approach has three characteristic features that distinguish it from any other strategies for social research. These in brief are: Use of qualitative and quantitative approaches within a single research project; Triangulation; and Pragmatist. As it is very important for the researcher to understand when it is appropriate to use a mixed methods approach (multi-strategy research), Bryman (2001) offered 10 ways in which it can be used:

1. The logic of triangulation: it may be used to offer support;
2. Qualitative research facilitates quantitative research: qualitative research can be used to generate quantitative studies;
3. Quantitative research facilitates qualitative research: quantitative research may tell how many or how often, and the qualitative research may seek to answer why;
4. Filling in the gaps;
5. Statistic and processual features: 'In some circumstances quantitative methods are used to study the more stable aspects of social life while qualitative methods are employed to study changes';

6. Researchers' and participants' perspectives: qualitative data may give a view to the perspectives of the people, while the quantitative information may tell researcher what they are trying to find;
7. The problem of generality: a small sample may be used for the qualitative element, while the quantitative element may be used to include a wider sample, therefore increasing the generality of the findings;
8. Qualitative research facilitating the interpretations of the relationship between the variables: i.e. quantitative research may identify patterns, while qualitative research can offer to explain the patterns;
9. Solving a puzzle: i.e. if the results of a research do not make sense and there is a need to clarify what has been found.
10. Studying different aspects of a phenomenon: i.e. quantitative methods might help one research what people thought of religion and qualitative research might research how religious beliefs and rituals affected behaviour;

Alternatively, there are some limitations and disadvantages associated with the use of mixed methods. For instance, if the rationale for combining quantitative and qualitative research is not made explicit, it becomes difficult for the reader to judge what has been gained by employing both approaches (Bryman, 2004). Also, observation or results gained from different approaches could be time consuming or misfit and difficult to integrate (Denscombe, 2007).

A2.3 Data Sources for Research

Researchers need to consider the sources of information on which to conduct, support and confirm their research and findings. There are two main categories of sources: primary sources and secondary sources. Researchers should always consider secondary research options first with careful consideration to its reliability and validity. Similarly, when choosing and developing primary sources, researchers must consider the most appropriate method to include its reliability, validity and practicality (Institute of Lifelong Learning, 2009). A comparison of these two data sources is shown in Table A2.2.

Table A2.2: Comparison between Primary and Secondary Research (Dunsmuir & Williams, 1992)

Category	Primary Sources	Secondary sources
Definition	Data collected by the researcher themselves (considered first hand information)	Data that already exists (considered second hand sources of data)
Examples	Questionnaires, interviews, case studies, action research, and observations	Previous research, official statistics, government reports, historical data, and web information
Benefits	• Original data; • Addresses specific research issues as the researcher controls the search design to fit their needs. i.e. the researcher can decide on such requirements as size of project, funds, time frame, location of research and the way data is collected	• Cheap and accessible - especially a University Library; • May be useful for putting the research into context; • Often the only resource, for example historical documents; • Can be used to set the scene of the research and its findings.

A2.4 Methods of Data Collection

For any study that extends beyond a review of literature, a key issue is the collection of data (Fellows & Liu, 2008). The objective here is choosing the most suitable data collection method that will enable the researcher to obtain an appropriate set of data; which will in turn permit the research to realise its aims and objectives (Fellows & Liu, 2008). There are several methods of collecting primary data, particularly in surveys and descriptive researches. The most common ones are through questionnaires, interviews and observation methods (Kothari, 2009). Hence, understanding the benefits and the limitations of research techniques is vital to the success of any research study (Fellows & Liu, 2008). Therefore, Tables A2.3 and A2.4 have been adapted using different sources to evaluate the strengths and disadvantages of the data collection methods being utilised in this study.

Table A2.3:- Strengths and Weaknesses of Interviews (structured, semi-structured, or open ended) (Thomas *et al.*, 2005; Bimingham City University, 2006)

Advantages	Disadvantages
• Useful to obtain detailed information about personal feelings, perceptions and opinions; • Allow more detailed questions to be asked; • Ambiguities can be clarified and incomplete answers followed up; • Precise meaning of questions can be clarified; • Some interviewees may be less self-conscious in a one-to-one situation.	• They can be very time-consuming: setting up, interviewing, transcribing, analysing, feedback, and reporting; • They can be costly; • Different interviewers may understand and transcribe interviews in different ways; • Researcher may introduce their bias; • Data analysis is difficult to perform; • Geographic limitations, particularly for face to face interviews.

Table A2.4: Strengths and Weaknesses of Electronic Questionnaire Surveys (Barribeau *et al.*, 2005)	
Advantages	**Disadvantages**
• Cost-savings; • Ease of Editing/Analysis; • Faster Transmission Time; • Higher Response Rate; • More Candid Response - respondents may answer more honestly with electronic surveys than with paper surveys or interviews because confidentiality and anonymity is more assured; • Potentially Quicker Response Time with Wider Magnitude of Coverage; • Could be used as a method to ask for follow-up interviews.	• Population and sample is limited to those with access to computer and online network; • Creating the format of a computer questionnaire can be more difficult the first few times, due to a researcher's lack of experience; • Potential Technical Problems with Hardware and Software; • More instruction and orientation to the computer online systems may be necessary for respondents to complete the questionnaire; • Lacks opportunity to clarify responses

A2.5 Data Sampling

Sampling is the process of selecting units (e.g., people, organizations) from a population of interest so that by studying the sample we may fairly generalize our results back to the population from which they were chosen; i.e. the sample is representative (Trochim, 2006). Given an extremely large population (e.g. professional practitioners in the UK construction industry), whilst the population is actually finite, for practical considerations of time, cost, resources, etc., the population is taken as infinite. In such cases, when the population is

sufficiently large 'random sampling' (also known as probability sampling) will be appropriate. Alternatively a 'structured sample' could be more convenient. However, such a structured sampling needs a 'sampling frame' to be created explicitly (Fellows & Liu, 2008). That is because if the sampling frame is inappropriate i.e., a biased representation of the population, it will result in a systematic bias; where the latter causes incorrect inferences (Coughlan *et al.*, 2007; Kothari, 2009). Within this sampling frame, random sampling, judgement sampling, or non random sampling may be used (Fellows & Liu, 2008).

Nevertheless, as sample surveys involve the study of a small portion of the population, as mentioned above, there would naturally be a certain amount of inaccuracy in the information collected. This inaccuracy may be termed as sampling error or error variance (Kothari, 2009). The meaning of sampling error is clearly demonstrated in Figure A2.1 below.

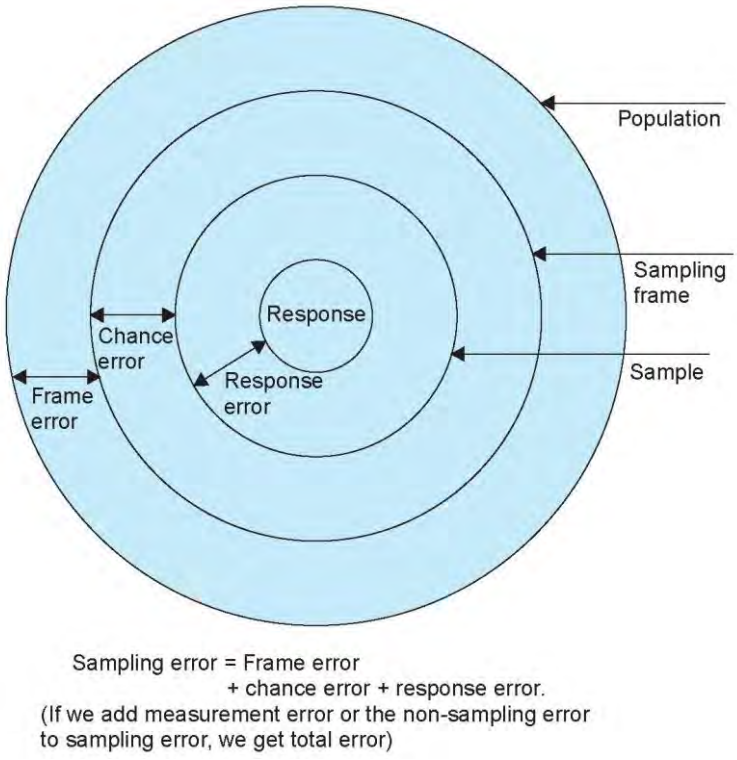


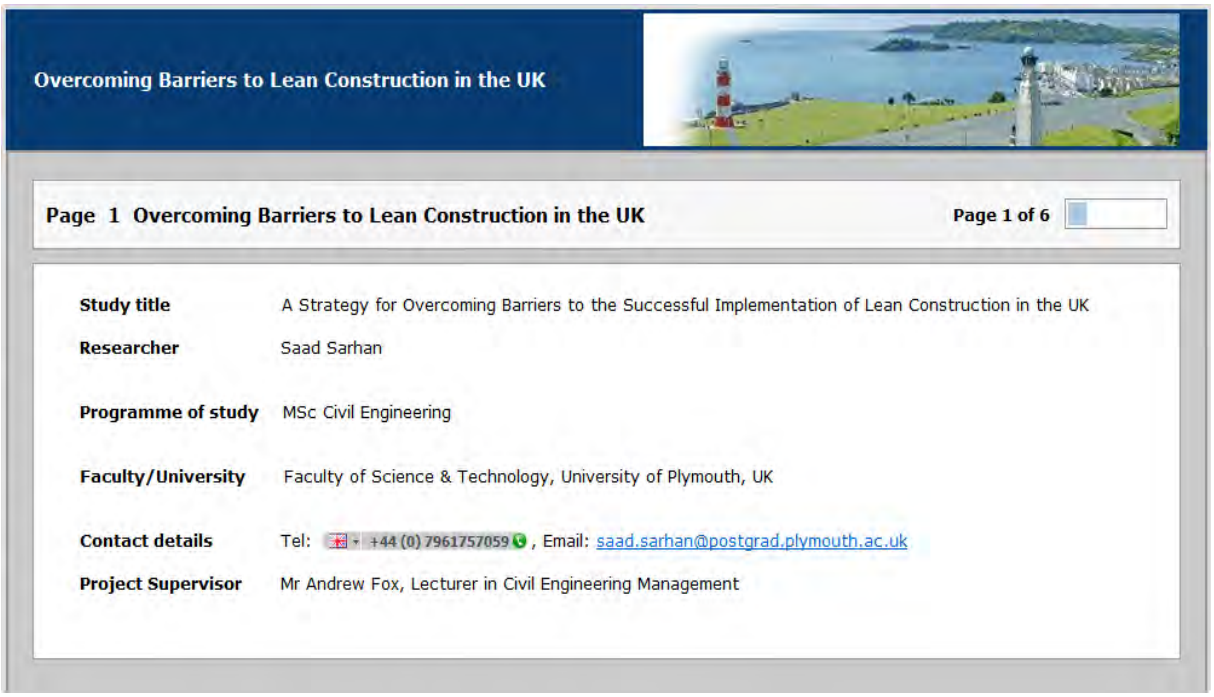
Figure A2.1: The meaning of Sampling Error (Kothari, 2009)

In fact, researchers prefer random sampling (probabilistic) methods over non-probabilistic ones, and consider them to be more accurate and precise. However, in applied social research there may be circumstances where it is not practical, feasible, or theoretically sensible to perform random sampling due to project constraints; and because of these limitations it often becomes necessary to employ another sampling technique, the non-probability sampling technique (Fellows & Liu, 2008; Castillo, 2009; Kothari, 2009). Please see Figure A2.2.

	Representation basis	
Element selection technique ↓	Probability sampling	Non-probability sampling
Unrestricted sampling	Simple random sampling	Haphazard sampling or convenience sampling
Restricted sampling	Complex random sampling (such as cluster sampling, systematic sampling, stratified sampling etc.)	Purposive sampling (such as quota sampling, judgement sampling)

Figure A2.2: Basic Sampling Designs (Kothari, 2009)

APPENDIX 3: INFORMATION SHEET FOR PARTICIPANTS



Overcoming Barriers to Lean Construction in the UK

Page 1 Overcoming Barriers to Lean Construction in the UK Page 1 of 6

Study title	A Strategy for Overcoming Barriers to the Successful Implementation of Lean Construction in the UK
Researcher	Saad Sarhan
Programme of study	MSc Civil Engineering
Faculty/University	Faculty of Science & Technology, University of Plymouth, UK
Contact details	Tel: +44 (0) 7961757059, Email: saad.sarhan@postgrad.plymouth.ac.uk
Project Supervisor	Mr Andrew Fox, Lecturer in Civil Engineering Management

Dear Participant,

You are being invited to take part in a research study as part of an MSc dissertation at the University of Plymouth, UK. Please take time to read the following information carefully.

The purpose of the study

Aim:

The aim of this research is to evaluate lean construction, as practiced in the UK, to identify barriers that may prevent its successful implementation and to propose a strategy for overcoming the barriers identified.

Objectives:

- Review literature relating to lean construction as practiced in the UK
- Identify barriers to the successful implementation of lean construction principles
- Evaluate the effect of barriers on the successful implementation of lean construction in the UK
- Propose a strategy to overcome the barriers identified

ADDITIONAL INFORMATION

Do I have to take part?
It is up to you to decide whether or not to take part and you are free to withdraw at any time.

Will what I say in this study be kept confidential?
All information collected for this study will be kept strictly confidential and full anonymity of participants will be ensured during the collection, storage and publication of research material in accordance with University of Plymouth policies and procedures.

What will happen to the results of the research study?
The results will be used in a postgraduate MSc dissertation and participants can request a copy of the published research or take part in a debriefing exercise at the end of the project.

Contact for Further Information
If you have any concerns about the way in which the study has been conducted, you may contact the project supervisor (contact details below).

Mr Andrew Fox
Lecturer in Civil Engineering Management
University of Plymouth
Faculty of Technology
Department of Engineering
Drakes Circus
Plymouth
Devon, UK
PL4 8AA
Tel: +44 (0) 1752 586120
Email: andrew.fox@plymouth.ac.uk

Thank you for taking the time to read this information sheet

Date
August 2011

APPENDIX 4: FEEDBACK RECIEVED FROM PILOT STUDIES

Author: Do you have any remarks/comments regarding the clarity of the questions and the overall structure of the questions on this page?

Participant	Page 1 – Questions 1-9 (Background)
Supervisor	Ok.
Professor	No
Senior Engineer	no
Graduate-Engineer	Ideal, but question 7 could have more categories, most deal with the construction industry as a whole
MSc Student	N/A

Participant	Page 2 – Questions 10-17 (Soft aspects of lean)
Supervisor	At the top, should it say "the five main principles of lean construction are:"
Professor	No
SeniorEngineer	no
Graduate-Engineer	If you haven't heard of Lean Construction Institution some of the questions become irrelevant.
MSc Student	N/A

Participant	Page 3 – Questions 18-28 (Hard aspects of Lean)
Supervisor	All seems ok
Professor	No
Senior Engineer	no
Graduate-Engineer	Didn't have knowledge of some of the questions mainly the questions where "don't know" was shown, not all areas of a company are known.
MSc Student	N/A

Participant	Page 4 – Questions 29-33 (Outcomes of LC)
Supervisor	Seems ok
Professor	No
Senior Engineer	no
Graduate-Engineer	Question 36 would be more targeted at the upper management in the companies.
MSc Student	N/A

Participant	Page 5 – Questions 34-36 (Barriers)
Supervisor	Seems ok
Professor	No
Senior Engineer	no
Graduate-Engineer	Maybe mention what the follow up interview entails.
MSc Student	N/A

APPENDIX 5: BACKGROUND DETAILS - QUESTIONS 1-9

A5.1 Background Details: Questions 1-9

These set of questions were included to determine the nature and the background of the participants and their organisations. This data obtained was then used by the author to conduct the secondary analysis.

Question 1

Table A5.1: Profession of the participants (Author)

1. What is your profession?

	Responses	Percent
Academic:	5	3.57%
Technician:	2	1.43%
Civil Engineer:	47	33.57%
Qunatity Surveyor:	2	1.43%
Architect:	6	4.29%
Designer:	3	2.14%
Consultant:	16	11.43%
Construction Manager:	15	10.71%
Project Manager:	14	10%
If other, please specify:	30	21.43%
Total Responded to this question:	140	100%
Total who skipped this question:	0	0%
Total:	140	100%

This question was used to identify the profession of the participants. The results from this question are also shown in Figure A5.1 below. As noticeable, the largest proportion of the participants was for civil engineers. Thirty of the participants selected the 'other' option which included a text box so they can enter their precise profession. This option was included for flexibility, and to obtain accurate description of the participants within the research study; which is required so as to provide evidence to the generality of the findings.

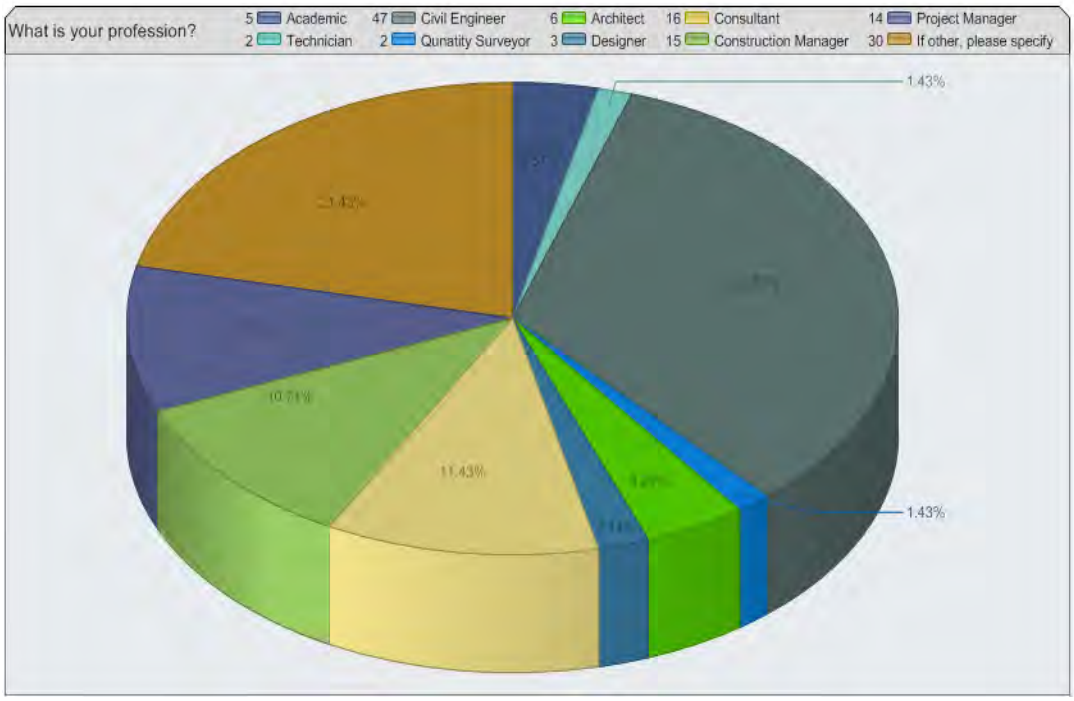


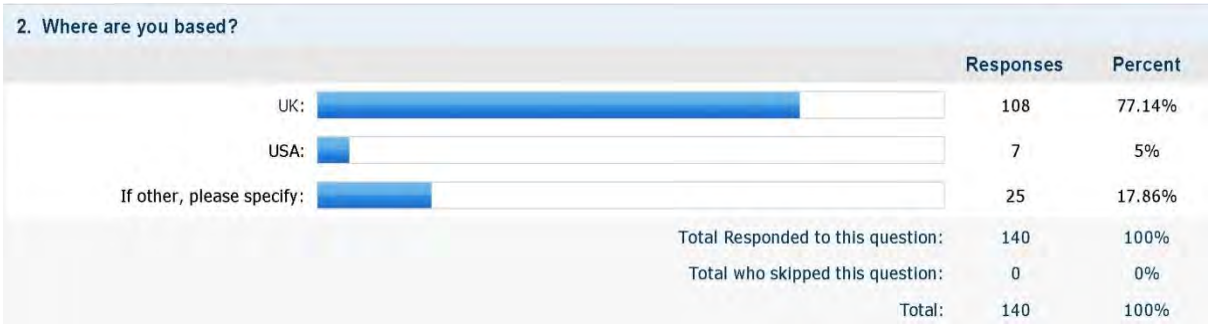
Figure A5.1: Profession of the participants (Author)

As mentioned previously, the largest two groups were civil engineers and those who selected the 'other' option, representing 33.57% and 21.43% of all participants respectively. The next largest group of participants were the consultants, construction managers, and project managers which represented 11.43%, 10.71%, and 10% of all participants in respective order. Architects represented 4.29% of the participants, 3.57% were academics, 2.14% were designers, and finally each of the technicians and quantity surveyors represented 1.43% of all participants. Some of the professions (e.g. designers and quantity surveyors) had a small percentage of participation because some of them preferred to select the 'other' option. The latter included a wide range of professions (the full list can be found in Appendix 12) such as: design manager, structural engineer, construction director, planning claims manager, head of procurement, planning director, quality/business improvements manager, geo-engineer,

dimensional control engineer, general manager, contract sales manager, project engineer, researcher, supplier to construction market, etc.

Question 2

Table A5.2: Location of the participants (Author)



2. Where are you based?

	Responses	Percent
UK:	108	77.14%
USA:	7	5%
If other, please specify:	25	17.86%
Total Responded to this question:	140	100%
Total who skipped this question:	0	0%
Total:	140	100%

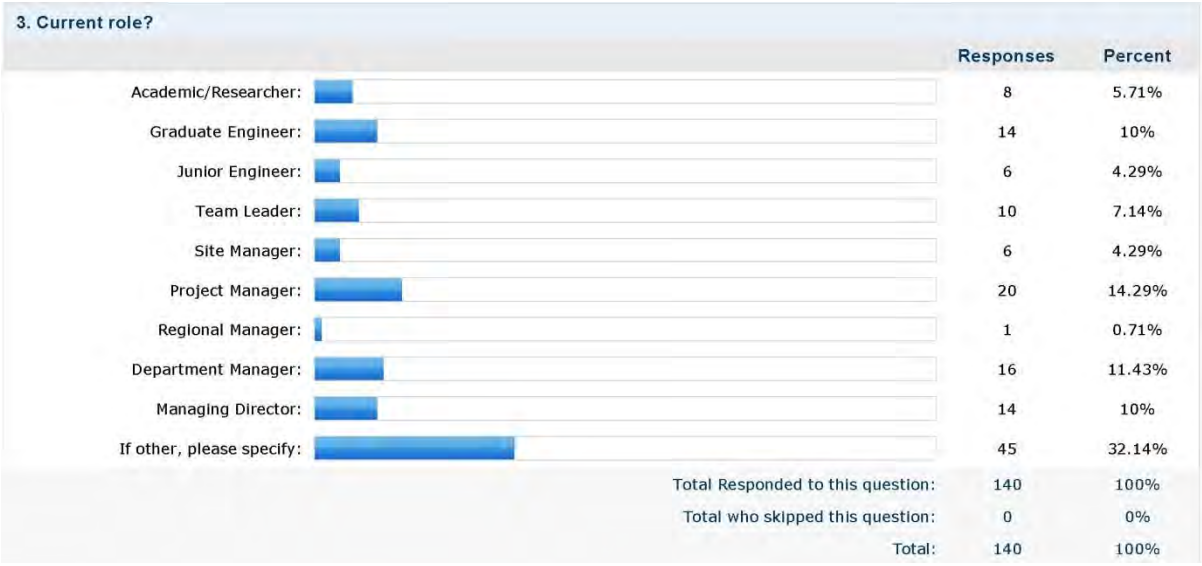
This question was included to determine where the participants are based; and to be used for secondary analysis, by comparing between LC practices in the UK, USA and other international countries.

As can be seen from Table A5.2 above, 77.14% of all participants were based in the UK, 17.86% in other international countries, and only 5% in the USA. The participants who selected the 'other' option were based in different international countries such as: Republic of Ireland, Netherlands, Italy, Australia, Canada, Peru, China, Pakistan, India, Singapore, State of Qatar, Egypt, Nigeria, Kenya, and Sri Lanka.

Hence, very few responses were obtained from respondents who are based in the USA (only seven responses) and many of those based in international countries have not completed the survey, this comparison was excluded from the secondary analysis.

Question 3

Table A5.3: Current role of the participants (Author)



3. Current role?

	Responses	Percent
Academic/Researcher:	8	5.71%
Graduate Engineer:	14	10%
Junior Engineer:	6	4.29%
Team Leader:	10	7.14%
Site Manager:	6	4.29%
Project Manager:	20	14.29%
Regional Manager:	1	0.71%
Department Manager:	16	11.43%
Managing Director:	14	10%
If other, please specify:	45	32.14%
Total Responded to this question:	140	100%
Total who skipped this question:	0	0%
Total:	140	100%

This question was included to determine the current role of the participants. This was essential to ensure that all participants of the survey are currently involved in the construction industry, and thus have up-to-date first hand knowledge. It was also included to be used for secondary analysis by comparing between the participants according to their managerial position; where the respondents were divided into three groups. The first included graduate and junior engineers; the second included team leaders, site managers and project managers; while the third included regional managers, department managers, and managing directors. Respondents who selected the 'Other' option were excluded from the secondary analysis.

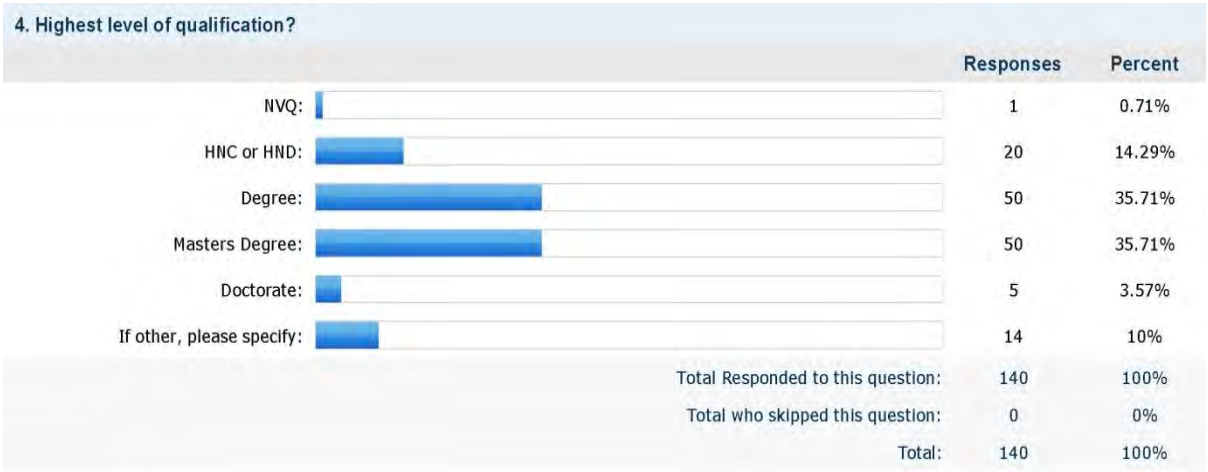
As can be seen in Table A5.3, the majority of the participants were holding senior positions at their respective organisations. Also, around 6% of the participants were academics/researchers. Forty five respondents selected the 'other' option and entered their specific roles into the comment box. The full list can be found in Appendix 12. However this list included the following roles: technical director, marketing director, divisional director, ,

senior consultant, pre-contract manager, works coordinator, senior quantity surveyor, contracts commercial manager, section engineer, corporate responsibility, chief construction engineer, design manager, setting out engineer, business unit manager, architect, planning manager, etc.

As noticeable, the responses obtained from this question have undoubtedly shown the wide diversity of the participants' current roles. It is also very interesting that the list of 'others' included some very specific/specialist roles, such as: owner of an independent consultancy, professional speaker to the construction industry, specialist blast consultant, estimator, property developer, training engineer, and lean project delivery consultant.

Question 4

Table A5.4: Qualification of the participants (Author)



4. Highest level of qualification?	Responses	Percent
NVQ:	1	0.71%
HNC or HND:	20	14.29%
Degree:	50	35.71%
Masters Degree:	50	35.71%
Doctorate:	5	3.57%
If other, please specify:	14	10%
Total Responded to this question:	140	100%
Total who skipped this question:	0	0%
Total:	140	100%

This question was placed to identify the qualification set of the participants. Also, to be used for secondary analysis by comparing between the participants according to their educational level; where respondents were divided into three groups. The first included those holding NVQ and HNC/HND qualifications; the second included those holding a bachelors degree;

while the third included those holding a masters degree. Respondents holding a doctorate degree and those who selected the 'Other' option were excluded from the secondary analysis.

As can be seen from Table A5.4, most of the participants were holding bachelors and masters degrees. Each of these groups had an equal representation of 35.71% of all participants. Those holding NVQ and HNC/HND qualifications represented about 15%, while only 3.57% of the participants were holding a doctorate degree. Also 10% of the participants selected the 'other' option. Some of the qualifications of the 'Other' category included: postgraduate certificate, postgraduate diploma, Irish achieved diploma - equivalent to BEng, professional memberships (e.g. MICE), and foundations degree. To view the full list, please refer to Appendix 12.

The results from Table A5.4 above demonstrate that the research was able to capture a well rounded mixture of professionals, based on their highest level of qualification. Another important observation obtained from the results of this question is the large percentage of participants holding postgraduate qualifications, i.e. masters degree.

Question 5

Table A5.5: Years of experience of the participants (Author)

5. Years of experience?	Responses	Percent
0-5:	33	23.91%
5-10:	18	13.04%
10-20:	36	26.09%
20+:	51	36.96%
Total Responded to this question:	138	98.57%
Total who skipped this question:	2	1.43%
Total:	140	100%

This question was included as it provides a tool for distinguishing between the participants according to their years of experience. As can be seen from Table A5.5 above, the highest proportion of participants were those who have more than 20 years of experience and represent almost 37% of all respondents. The group which came next is those having 10-20 years of experience, representing about 26% of all respondents. Respondents with 0-5 years of experience came third (almost 24%), and finally 13% of the respondents have 5-10 years of experience. However, when conducting the secondary analysis later in the report, the last two groups (0-5 and 5-10) will be merged together in one group. That group will comprise participants who have 0-10 years of experience, and represents approximately 37% of all participants.

It is obvious from the results in Tables 4.3 and 4.5, that more than half (63%) of the responses received were from professionals with more than 10 years of experience holding senior positions at the directional and managerial level in their respective. This definitely, enhances the validity of the sampling approach adopted (Trochim, 2006), and thus increases the reliability of the results achieved.

Question 6

Table A5.6: Number of employees within the participants' organisations (Author)

6. Number of employees in your organisation?

	Responses	Percent
0-250:	53	38.41%
250-500:	11	7.97%
500+:	74	53.62%
Total Responded to this question:	138	98.57%
Total who skipped this question:	2	1.43%
Total:	140	100%

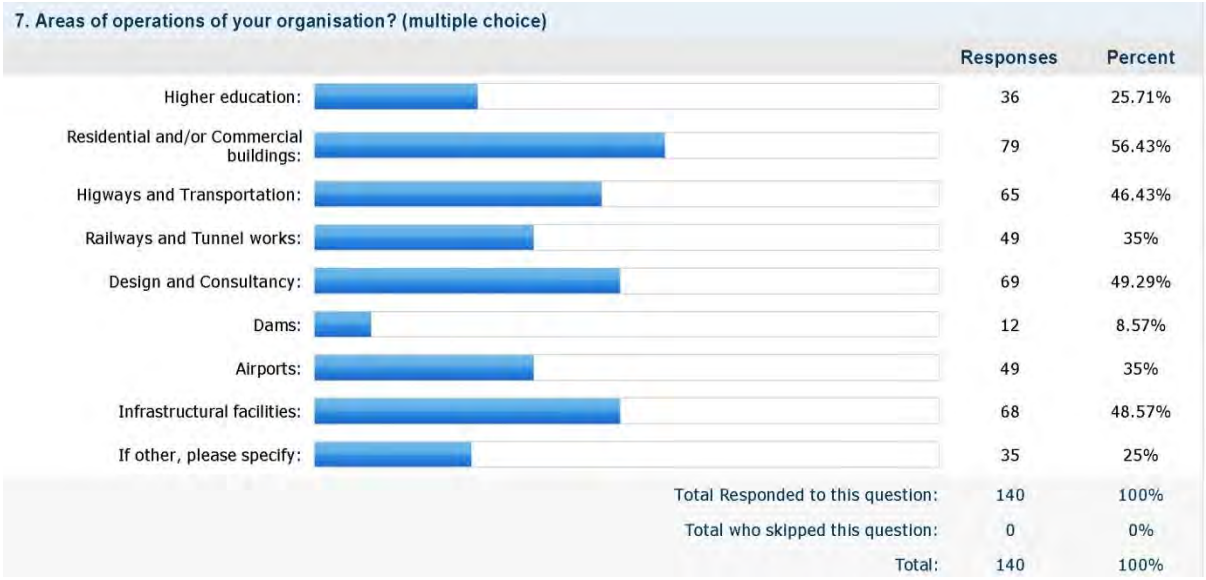
This question was included to be used for the secondary analysis. The author decided to investigate the effect of the number of employees within organisations on the lean implementation process, by comparing between organisations according to its size (number of employees).

As can be seen in Table A5.6 above, the majority of the respondents (53.62%) belonged to organisations which have more than 500 employees. The second group consisted of those who belonged to organisations which have less than 250 employees and represented 38.41% of all respondents; while only about 8% of the respondents belonged to organisations which have 250-500 employees.

It is very obvious that the responses recieved from this question have evidently shown the diversity of respondents from small to large organization based on the number of employees. However, when conducting the secondary analysis later in the report, the last two groups (0-250 and 250-500) will be merged together in one group. That group will include organisations with less than 500 employees, and represents approximately 46.38% of all responses.

Question 7

Table A5.7: Areas of operations of organisations (Author)



7. Areas of operations of your organisation? (multiple choice)

	Responses	Percent
Higher education:	36	25.71%
Residential and/or Commercial buildings:	79	56.43%
Higways and Transportation:	65	46.43%
Railways and Tunnel works:	49	35%
Design and Consultancy:	69	49.29%
Dams:	12	8.57%
Airports:	49	35%
Infrastructural facilities:	68	48.57%
If other, please specify:	35	25%
Total Responded to this question:	140	100%
Total who skipped this question:	0	0%
Total:	140	100%

The aim of this question was to identify the areas of operations of organisations involved in the survey, so as to ensure that the results are not biased towards certain specific areas of operations. As seen in Table A5.7 above, participants were given the ability to choose more than one answer (multiple choices) according to the areas of operations of their organisations. Also the 'other' option was provided to discover other different areas of operations not mentioned in the given tick boxes.

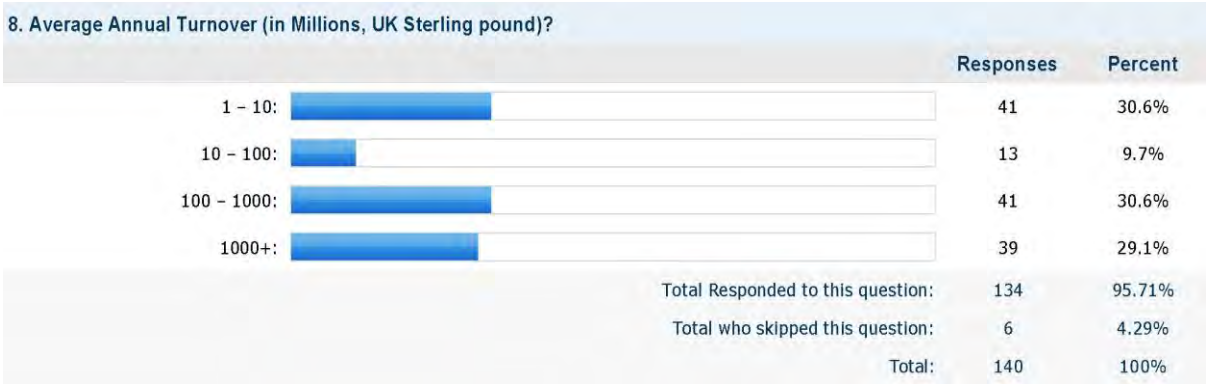
As noticeable (Table A5.7) the organisations involved in the survey are engaged in very broad areas of operations. Residential and/or commercial buildings received the highest number of responses (56.43%). This was followed by design and consultancy, infrastructure facilities, highways and transportation, railways and tunnel works, and airports which obtained a percentage score of 49.29%, 48.57%, 46.43%, 35%, and 35% respectively. Then comes higher education (e.g. universities and institutional buildings) with a score of about 25%, and finally dams with a score of 8.57%.

It is obvious that the distribution of areas of operations of organisations is almost even, with exception to only two areas of operations, namely, higher education and dams. However, these two are already known to be special areas of operations which do not occur as frequently as the others. Another important observation is that the following three areas of operations: highways, rails and airports received a high response rate.

On the other side, 25% of the participants selected the 'other' option. This category included a very wide range of interesting areas of operations such as: ports and harbours construction, hotels, schools, hospitals, rural roads and associated structures development, health care, and historic conservation. To view the full list, please refer to Appendix 12.

Question 8

Table A5.8: Average Annual turnover of organisations in Millions, UK sterling pound (Author)



8. Average Annual Turnover (in Millions, UK Sterling pound)?

	Responses	Percent
1 – 10:	41	30.6%
10 – 100:	13	9.7%
100 – 1000:	41	30.6%
1000+:	39	29.1%
Total Responded to this question:	134	95.71%
Total who skipped this question:	6	4.29%
Total:	140	100%

This question was included as it provides a tool for differentiating between organisations, according to their average annual turnover (AAT). The results shown in Table A5.8, illustrate that the research was successfully able to capture a very well distributed mixture of organisations based on their average annual turnover in Millions (UK sterling pound).

This study included most of the largest construction organisations in the UK. Almost 60% (59.7% exactly) of the responses received represent organisations which their average annual turnover (AAT) exceeds 100 Million UK sterling pounds. Alternatively about 40% of the responses represent organisations which its AAT is less than 100 Million UK sterling pounds. During the secondary analysis, organisations will be divided into three categories (1-100, 100-1000, and 1000+). That means that organisations which their AAT are £1-10 Million and £10-100 Million, will be merged together.

Question 9

Table A5.9: Major clients/customers of the organisations (Author)

9.
Major Clients/Customers?

	Responses	Percent
Public Organizations:	19	13.67%
Private Individuals and Organizations:	37	26.62%
Both:	83	59.71%
Total Responded to this question:	139	99.29%
Total who skipped this question:	1	0.71%
Total:	140	100%

This question is linked to question number 7, and it aims to identify the nature of clients/customers that deal with the organisations involved in this survey, in order to ensure that the results obtained are not biased towards certain types of clients. As can be seen from Table A5.9, the major clients/customers selected were 'both': public and private individual organisations with a percentage score of nearly 60% of all respondents. However, this category (those who selected the 'both' answer) will be excluded from the secondary analysis. The secondary analysis will be focussed on comparing between the other two specific categories (those who mentioned that they only deal with public organisations and those who only deal with private individuals & organisations).

APPENDIX 6: ORGANISATIONS' AAT CLASSIFICATION RESULTS & ANALYSIS

I. Organisation Turnover Sub-Classification Results & Analysis

Table A6.1: Organisation Turn-Over Sub-Classification Results & Analysis (Author)

Q. No	Turn Over [0-100]	Turn Over [100-1000]	Turn Over [1000+]
10	• Yes= 60%	• Yes= 70.97%	• Yes= 71.43%
11	• Mode= 1 • Median= 1 (Traditional) • Mean= 1.7	• Mode= 1 • Median= 2 (Learning) • Mean= 2.32	• Mode= 1 • Median= 3 (Leading) • Mean= 2.63
12	• Mode= 3 • Median= 3 (Leading) • Mean= 2.75	• Mode= 3 • Median= 3 (Leading) • Mean= 2.84	• Mode= 2 and 3 • Median= 3 (Leading) • Mean= 2.79
13	• Mode= 1 • Median= 2(Learning) • Mean= 2.32	• Mode= 1 • Median= 2 (Learning) • Mean= 2.38	• Mode= 1 • Median= 2 (Learning) • Mean= 2.70
14	• Mode= 1 • Median= 1 (Traditional) • Mean= 2.02	• Mode= 1 • Median= 2 (Learning) • Mean= 2.22	• Mode= 1 • Median= 2 (Learning) • Mean= 2.38
15	1. Long-Term Contractual Agreements= 59.09% 2. Document Management Systems= 52.27% 3. Collaborative Planning Schedules= 45.45% 4. PIS= 29.55% 5. Cross functional teams= 27.27% 6. IPD= 18.18% 7. LPDS= 9.09% 8. All= 6.82% 9. Other= 6%	1. Long-Term Contractual Agreements= 76.67% 2. Document Management Systems= 73.33% 3. Cross functional teams= 63.33% 4. PIS= 46.67% 5. Collaborative planning= 43.33% 6. IPD= 40% 7. LPDS= 23.33% 8. All= 23.33% 9. Other= 6%	1. Long-Term Contractual Agreements= 73.53% 2. Document Management Systems= 70.59% 3. Cross-Functional Teams= 61.76% 4. IPD= 47.06% 5. Collaborative planning= 44.12& 6. PIS= 41.18% 7. LPDS= 29.41% 8. All= 17.65% 9. Other= 8%
16	Statements they should disagree/strongly disagree with: 1) 62.23% 2) 75.55% 5) 33.33% Statements they should agree/strongly agree with:	Statements they should disagree/strongly disagree with: 1) 86.67% 2) 90% 5) 30% Statements they should agree/strongly agree with:	Statements they should disagree/strongly disagree with: 1) 76.47% 2) 82.36% 5) 41.17% Statements they should agree/strongly agree with:

	3) 64.45 % 4) 62.22% 6) 24.44% 7) 31.11% 8) 84.09% 9) 75% 10) 57.78% 11) 77.78% 8 correct out of 11 Average score= 58.9%	3) 56.67% 4) 50% 6) 30% 7) 30% 8) 100% 9) 53.34% 10) 60% 11) 90% 8 correct out of 11 Average score= 61.51%	3) 82.35% 4) 61.77% 6) 29.41% 7) 43.42% 8) 91.18% 9) 73.53% 10) 45.45% 11) 76.47% 7 correct out of 11 Average score= 63.96%
17	1. Workplace organisation= 58.14% 2. Standardised work= 58.14% 3. Problem solving= 51.16% 4. Collaborative planning= 41.86% 5. Data analysis= 39.53% 6. VM= 39.53% 7. Process mapping= 39.53% 8. Work sequence analysis= 27.91% 9. All= 11.63% 10. None= 11.63% 11. Other= 6%	1. Collaborative Planning= 50% 2. Data analysis= 50% 3. Workplace organisation= 43.33% 4. Process mapping= 40% 5. Work sequence analysis= 36.67% 6. VM= 33.33% 7. Standardised work= 33.33% 8. Problem solving= 33.33% 9. All= 26.67% 10. None= 13.33% 11. Other= 3%	1. Collaborative Planning= 61.76% 2. Data Analysis= 58.82% 3. Workplace organisation= 55.88% 4. Work sequence analysis= 52.94% 5. Visual management= 52.94% 6. Standardised work= 52.94% 7. Problem solving= 52.94% 8. Process mapping= 35.29% 9. All= 17.65% 10. Other= 11% 11. None= 5.88%
18	1. CPM= 48.84% 2. Look ahead= 41.86% 3. PCP= 30.23% 4. N/A= 25.58% 5. Workflow PM= 25.58% 6. Constraint analysis= 16.28% 7. LPS= 14% 8. RPS= 7% 9. Other= 6%	1. CPM= 76.67% 2. Look ahead= 53.33% 3. PCP tools= 50% 4. Workflow PM= 30% 5. LPS= 30% 6. Constraint analysis= 30% 7. RPS= 16.67% 8. N/A= 13.33% 9. Other= 6%	1. CPM= 69.7% 2. PCP tools= 57.58% 3. Look ahead= 51.52% 4. Constraint analysis= 33.33% 5. LPS= 18.18% 6. Other= 18.18% 7. Workflow PM= 15.15% 8. N/A= 12% 9. RPS= 9%
19	1. None= 56.82% 2. PDCA= 29.55% 3. Other= 11% 4. FRS= 9.05% 5. Prefabrication= 9.05%	1. PDCA= 46.67% 2. None= 33.33% 3. Prefabrication= 26.67% 4. Other= 13% 5. FRS= 10%	1. PDCA= 45.45% 2. None= 33.33% 3. Prefabrication= 33.33% 4. FRS= 18.18% 5. Other= 9%
20	1. N/A= 66.67% 2. VM= 19.05% 3. LPS= 11.9% 4. CFP= 9.52% 5. Other= 7%	1. VM= 37.93% 2. N/A= 34.48% 3. LPS= 27.59% 4. CFP= 20.69% 5. Crane= 13.79%	1. VM= 42.42% 2. N/A= 30.3% 3. LPS= 18.18% 4. CFP= 15.15% 5. Other= 15.15%

	6. Crane= 4.76%	6. Other= 6%	6. Crane= 9%
21	Yes= 18.6%	Yes= 76.67%	Yes= 56.25%
22	1. Don't know= 32.56% 2. N/A= 30.23% 3. JIT= 30.23% 4. VS analysis= 7% 5. Other= 2% 6. Kanban= 2%	1. Don't know= 50% 2. JIT= 26.67% 3. N/A= 16.67% 4. VS analysis= 10% 5. Other= 10% 6. Kanban= 3.33%	1. JIT= 34.28% 2. N/A= 25% 3. Don't know= 21.88% 4. Other= 15% 5. VS analysis= 12.5% 6. Kanban= 9.38%
23	1. N/A= 37.21% 2. None= 30.27% 3. BIM= 25.58% 4. VR tools= 9.3% 5. Other= 6% 6. DSM= 4.65% 7. VDS= 2.33%	1. BIM= 40% 2. DSM= 30% 3. None= 30% 4. N/A= 16.67% 5. VDS= 13.33% 6. VR tools= 13.33% 7. Other= 10%	1. BIM= 43.75% 2. VR tools= 21.88% 3. N/A= 21.88% 4. Other= 15% 5. None= 12.5% 6. DSM= 9.38% 7. VDS= 9.38%
24	1. N/A= 44.19% 2. None= 30.23% 3. Set based design= 16.28% 4. Concurrent design= 14% 5. Other= 11%	1. N/A= 31% 2. None= 31% 3. Concurrent design= 24.14% 4. Set based design= 20.69% 5. Other= 3%	1. N/A= 33.33% 2. N/A= 30.3% 3. Concurrent design= 24.24% 4. Set based design= 9.09% 5. Other= 9%
25	1. N/A= 74.42% 2. Performance measurement= 18.6% 3. Planning= 14% 4. Logistics= 9.3% 5. Management control= 9.3% 6. Production control= 4.65% 7. Other= 2%	1. N/A= 51.72% 2. Planning= 38% 3. Management control= 31% 4. Production control= 20.69% 5. Logistics= 20.69% 6. Performance measurement= 20.69% 7. Other= 0%	1. N/A= 50% 2. Planning= 28.12% 3. Production control= 28.12% 4. Performance measurement= 18.75% 5. Management control= 18.75% 6. Other= 12%
26	• Measures production planning effectiveness and workflow reliability=14%	• measures production planning effectiveness and workflow reliability= 14.81%	• measures production planning effectiveness and workflow reliability= 18.18%
27	1. Experience of managers= 59.52% 2. KPI= 52.38% 3. Process PM= 21.43% 4. Own metrics= 19.05% 5. None= 11.9% 6. International benchmarking= 9.52% 7. Balanced scorecards= 9.52% 8. LPS= 7.14% 9. DQI= 2.38% 10. QMPMS= 2.38%	1. KPI= 90% 2. Experience of managers= 53.33% 3. Own metrics= 36.67% 4. LPS= 30% 5. Process PM= 30% 6. Balanced scorecards= 26.67% 7. International benchmarking= 20% 8. DQI= 16.67% 9. QMPMS= 13.33% 10. Other= 6%	1. KPI= 90.91% 2. Experience of managers= 63.64% 3. Own metrics= 54.55% 4. Process PM= 33.33% 5. Balanced Scorecards= 21.21% 6. International benchmarking= 15.15% 7. LPS= 15.15% 8. QMPMS= 12.12% 9. DQI= 6.06% 10. Other= 3%

	11. Other= 2%	11. None= 0%	11. None= 3%
28	*Mean score for 'non-financial' performance indicators (Only those achieving a score of 8 and above will be considered)* 1. Safety= 9.325 2. Customer Satisfaction= 9.14 3. Quality= 8.813 4. Functionality= 7.928 5. Productivity= 7.907 6. Team performance= 7.674 7. Planning Efficiency= 7.604	*Mean score for 'non-financial' performance indicators (Only those achieving a score of 8 and above will be considered)* 1. Safety= 9.714 2. Customer Satisfaction= 8.93 3. Quality= 8.75 4. Functionality= 7.965 5. Productivity= 7.931 6. Team performance= 7.931 7. Planning Efficiency= 7.482	*Mean score for 'non-financial' performance indicators (Only those achieving a score of 8 and above will be considered)* 1. Safety= 9.545 2. Customer Satisfaction= 9.454 3. Quality= 8.67 4. Planning Efficiency= 7.757 5. Team performance= 7.727 6. Productivity= 7.515 7. Functionality= 7.272
29	1. Less waste= 75% 2. improved productivity= 67.5% 3. fewer defects and improved quality= 62.5% 4. Reduced cost= 60% 5. more client satisfaction= 57.5%	1. improved productivity= 86.67% 2. Less waste= 83.33% 3. Reduced cost= 76.67% 4. fewer defects and improved quality= 73.33% 5. more client satisfaction= 63.33%	1. Less waste= 69.7% 2. fewer defects and improved quality= 69.7% 3. improved safety and health 4. conditions= 57.58% 5. improved productivity= 57.58% 6. reduced cost= 51.52%
30	1. Cost and Value Management= 61% 2. Risk management= 53.66% 3. LC= 22% 4. SC assistance= 22% 5. All= 22% 6. Other= 9%	1. Risk management= 62% 2. Cost and Value management= 58.62% 3. SC assistance= 38% 4. All= 31% 5. LC= 13.79% 6. Other= 3%	1. Risk management= 48.48% 2. Cost and Value management= 48.48% 3. All= 27.27% 4. LC= 15.15% 5. SC assistance= 15.15% 6. Other= 3%
31	1. BREEAM= 31.71% 2. International standards= 29.27% 3. N/A= 26.83% 4. LC= 14.63% 5. Other= 12% 6. All= 7.32% 7. SC assistance= 7.32%	1. International standards= 70% 2. BREEAM= 46.67% 3. SC assistance= 36.67% 4. LC= 16.67% 5. N/A= 10% 6. All= 10% 7. Other= 3%	1. International standards= 56.25% 2. BREEAM= 40.62% 3. SC assistance= 25% 4. All= 15.62% 5. Other= 6% 6. N/A= 6% 7. LC= 6.25%
32	1. In-house training= 35.71% 2. Job knowledge and Skills scheme= 33.33% 3. Team development= 28.57%	1. In-house training= 60% 2. Community engagement 56.67% 3. Safety programmes= 50% 4. Job knowledge and Skills	1. In-house training= 54.55% 2. Community engagement= 45.45% 3. Safety programmes= 33.33%

	4. Community engagement= 26.19% 5. N/A= 16.67% 6. Lean culture= 14.29% 7. Safety programmes= 14.29% 8. Other= 11% 9. All= 4.76%	scheme= 43.33% 5. Team development= 33.33% 6. Lean culture= 20% 7. All= 10% 8. N/A= 6.67% 9. Other= 3%	4. Job knowledge and Skills scheme= 24.24% 5. All=21.21% 6. Team development= 18.18% 7. Lean culture= 15.15% 8. Other= 12% 9. N/A= 3%
33	1. To improve our rate of client satisfaction= 53.85% 2. To increase our profit= 54% 3. To improve the quality of our outputs= 46.15% 4. To keep up-to-date= 28.21% 5. As a respond to the Egan's report= 15.38% 6. We are satisfied, no need to change= 12.82% 7. Other= 12% 8. When a major problem occurs= 10.26%	1. To improve the quality of our Outputs= 63.33% 2. To increase our profit= 60% 3. To improve our rate of client satisfaction= 56.67% 4. To keep up-to-date= 36.67% 5. As a respond to the Egan's report= 23.33% 6. When a major problem occurs= 10% 7. We are satisfied, no need to change= 3.33% 8. Other= 3.33%	1. To improve our rate of client satisfaction= 51.52% 2. To increase our profit= 45.5% 3. To improve the quality of our outputs= 42.42% 4. To keep up-to-date= 39.39% 5. Other= 27% 6. As a respond to the Egan's report= 12.12% 7. We are satisfied, no need to change= 9% 8. When a major problem occurs= 9%
34	*Only barriers with a mean score of 4.0 and above will be classified as significant barriers*: Fragmentation & subcontracting= 3.977 Procurement & contracts= 3.744 Lack of adequate Lean awareness = 4.256 Cultural issues= 3.953 Time & commercial pressure= 3.907 Financial issues= 3.581 Lack of top management commitment= 4.163 Design/Construction Dichotomy= 3.476 Educational issues= 3.767 Lack of process based PMS= 3.721	*Only barriers with a mean score of 4.0 and above will be classified as significant barriers*: Fragmentation & subcontracting= 3.719 Procurement & contracts= 3.594 Lack of Lean awareness= 4.469 Cultural issues= 4.031 Time & commercial pressure= 3.806 Financial issues= 3.188 Lack of top management commitment= 3.938 Design/Construction Dichotomy= 3.484 Educational issues= 3.594 Lack of process based PMS= 3.469	*Only barriers with a mean score of 4.0 and above will be classified as significant barriers*: Fragmentation & subcontracting= 3.688 Procurement & contracts= 3.844 Lack of Lean awareness = 4.212 Cultural issues= 4.152 Time & commercial pressure= 3.879 Financial issues= 3.576 Lack of top management commitment= 4.030 Design/Construction Dichotomy= 3.313 Educational issues= 3.438 Lack of process based PMS= 3.469
35	• Yes= 13.95%	• Yes= 12.9%	• Yes= 36.36%
36	• Yes= 31.82%	• Yes= 53.12%	• Yes= 45.16%

II. Organisation Turnover Sub-Classification In-depth Analysis

Q10- it seems that respondents who belong to small organisations are slightly less aware of the LCI-UK than those who belong to larger organisations (range 60% - 71%).

Q11- it is obvious that there is no change in modal responses. Alternatively, by focussing on the median responses there seems to be significant variations, as respondents belonging to large organisation (1000+) showed very optimistic responses. However, this optimistic evaluation then decreases steadily as the turnover of organisations decreases. A summary of these results is provided in table A6.2 below.

Table A6.2: Level of lean capability learning, based on the organisation turnover sub-classification analysis (Author)

Turnover of Organisations in Millions sterling	Mode value	Mean value	Median value	Classification based on median values
1-100	1	1.7	1	Traditional
100-1000	1	2.32	2	Learning
1000+	1	2.63	3	Leading

Q12- there seems to be no change in the median responses (All agree on Leading). However there are slight changes in the modal responses, as respondents belonging to large organisations provided less optimistic responses than the others, but on contrast they obtained the highest mean values. These results are shown in Figure A6.1

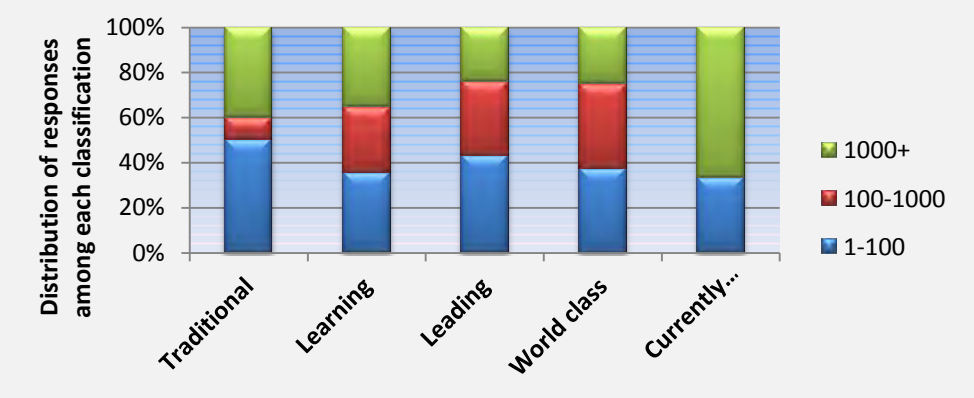


Figure A6.1: The evaluation of leaders' motivation abilities within construction organisations, based on the organisation turnover sub-classification analysis (Author)

Q13- there seems to be no change in both modal and median responses; but little variation in the mean values as large organisations obtained the highest score declining steadily as turnover decreases. Furthermore, by focussing on the right hand side of Figure A6.2 below, particularly from the leading to currently invincible criteria it appears that respondents who belong to large organisations provided more optimistic evaluations as the level of lean commitment increased, as opposed to those who belong to small organisations**.**

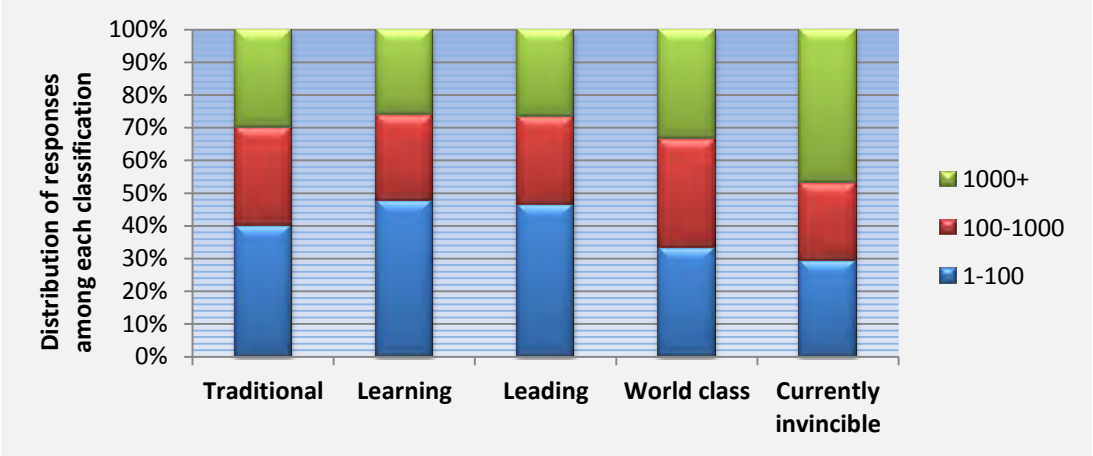


Figure A6.2: The evaluation of lean commitment within construction organisations, based on the organisation turnover sub-classification analysis (Author)

Q14- there seems to be no change in the modal responses; however, the median responses show marked variations as respondents who belong to large and medium organisations suggest some training, but those belonging to small organisations suggest no training. These results are summarised in Table A6.3.

Table A6.3: Level of lean awareness/understanding within organisations, based on

Organisation	Mode	Mean	Median	Classification based on
1-100	1	2.02	1	Traditional
100-1000 1000+	1	2.22	2	Learning
1000+	1	2.38	2	Learning

Q15- it is obvious that all agree on top two: long term contractual agreements and document management systems. Also, all agree on bottom three: LPDS, All, and Other. However, LPDS was selected by 29.41% of the respondents who belong to large organisations declining significantly as turnover decreases; but respondents who belong to medium organisations showed more consistent responses as both: All and LPDS were selected equally (23.33%). Another important observation is that large organisations put IPD as 4th (47.06%) decreasing significantly as turnover decreases (range 18.18% - 47.06%).

Q16- by referring to the organisation turnover sub-classification analysis, it appears that turnover makes a little difference to the level of understanding of lean concepts and practices, as large organisations obtained the highest score (63.96%) declining slightly as turnover decreases (range 58.9% - 63.96%). However, small and medium organisations were able to answer 8 statements correctly; while large organisations were able to illustrate their awareness of lean concepts to 7 statements only as they were the only group amongst all which did not agree with S10 (they achieved a frequency score= 45.45%). This statement (S10) mentions that any procurement form that tends to delegate design work to external designers, separates the design from the construction process; and therefore misses the lean aim of collaboration and integration (Johansen & Walter, 2007).

Q17- by referring to the organisation turnover sub-classification, it appears that both medium and large organisations agree on top three: collaborative planning, data analysis, and then workplace organisations; but small organisations prioritise tasks differently. For instance, the latter put work lace organisation, standardised work and problem solving as 1st, 2nd and 3rd respectively; but the others ranked them significantly lower.

Q18- it is obvious that LPS is used more frequently in larger organisation (in terms of turnover and number of employees) than in smaller organisations.

Q19- it appears that those who belong to larger organisations are the most aware of the techniques used for minimising uncertainty in production processes, as they put PDCA as number 1 according to their modal responses.

Q20- Within larger organisations (100-1000 and 1000+) the visual management technique was selected by 46.67% and 45.45% of the respondents respectively, and it came 1st in the modal ranking. While in case of smaller organisations (1-100) only 29.66% of the respondents selected the visual management technique, and it came 2nd in their modal ranking (after the option 'None'). When it comes to the frequency of using LPS for organising the movement of materials, crews and production processes, medium organisations come 1st (27.59%), followed by large organisations (18.18%) and then small ones (11.9%).

Q21- there seems to be very significant variations as medium organisations came first (76.67%), then large organisations (56.25%), and finally smaller organisations (only 18.6%), as shown in Figure A6.3 below.

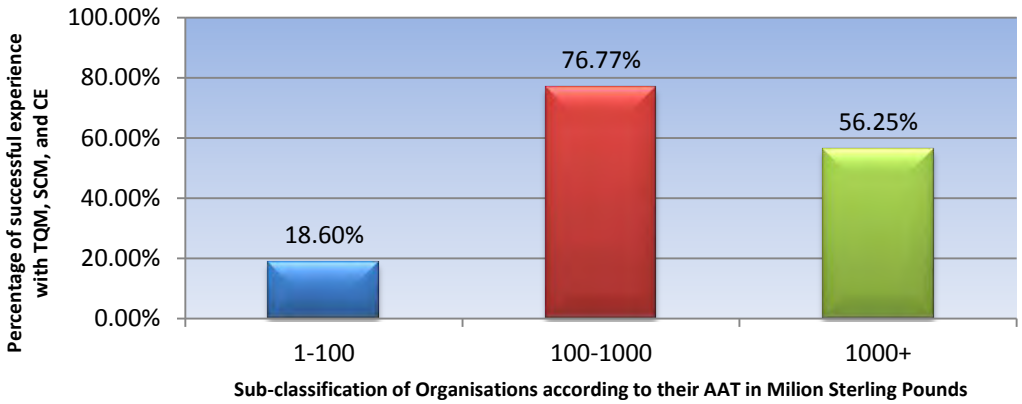


Figure A6.3: The amount of 'successful' experience with principles of TQM, SCM and CE, based on the organisation turnover sub-classification analysis (Author)

Q22- it is noticeable that there is a change in the modal responses based on turnover. JIT technique ranked 1st in case of large organisations (1000+), 2nd in case of medium organisations (100-1000); and 3rd in case of small organisations (1-100).

Q23- it appears that the turnover of organisations makes a significant difference to the frequency of using BIM; as larger organisations (100-1000 and 1000+) ranked BIM as 1st while small organisations put it considerably lower (range 25.58% - 43.75%). Also, large

organisations ranked DSM as second while medium and small organisations put it significantly lower (range 4.65% - 30%).

Q24- it appears that in all cases, the 'None' and 'Not Applicable' options always figured in the top two modal responses. No other consensus otherwise.

Q25- One significant observation is that LPS is used for production control in larger organisations much more frequently than in smaller ones (Table A6.4).

Table A6.4: The relation between Turnover of Organisations and the frequency of using LPS for Production Control (Author)

Modal Order	Turnover (0-100)	Turnover (100-1000)	Turnover (1000+)
2	Performance measurement=18.6%	Planning= 38%	Planning= 28.12%
3	Planning= 14%	Management control= 31%	Production control= 28.12%
4	Logistics= 9.3%	Production control= 20.69%	Performance measurement= 18.75%
5	Management control= 9.3%	Logistics= 20.69%	Management control= 18.75%
6	Production control= 4.65%	Performance measurement= 20.69%	Other= 12%

Q26- it seems that turnover makes very little difference to the awareness/understanding of the function of the PPC value in LPS (range 14% - 18.18%).

Q27- it appears that small organisations (1-100) rely mostly on experience of managers, while in case of larger organisations (100-1000 & 1000+) 90% of the respondents who belong to these organisations agree that results based KPI is the most commonly used. Another clear observation is that the larger organisations (based on turnover and size) have a higher tendency to establish their own metrics which is consistent with their business strategy and includes leading indicators aiming to provide them with early warnings.

Q28- it appears that all sub-classifications agree on top 3 (safety, client/customer satisfaction, and then quality).

Q29- it appears that large organisations employees are the only ones aware of the 'improved safety and health conditions' benefit that could be achieved from applying lean principles to construction. In both cases, it achieved a weighting score of about 57%.

Q30- there seems to be some important observations. First, in larger organisations (100-1000 and 1000+), risk management & mitigation ranked 1st, but in small organisations (1-100) cost & value management figured 1st. Also, in all three groups, 'Other' figured at bottom. Alternatively, LC figured 3rd in cased of small organisations with a score of 22%; while it figured 4th in case of large organisations with a score of 15.15%, and figured 5th in case of medium organisations with a score of 13.79%. When it comes to supply-chain assistance, medium organisation are the most aware of its importance (38%, 3rd rank), then small organisations comes next (22%, 4th rank), but large organisations are the least aware (only 15.15%, and 5th rank).

Q31- it appears that larger organisations rely mostly on international standards (e.g. ISO 14001), while in case of small organisations (1-100) the BRE environmental assessment model (BREEAM) comes first. Also, it is clear that large organisations, in general, pay more attention to environmental considerations. That can be evidenced from the amount of respondents in each group who selected the 'Not applicable' and 'All' options (Figure A6.4 below). Alternatively, when it comes to the application of LC and supply-chain assistance as ways for achieving environmental considerations, medium organisations take the lead.

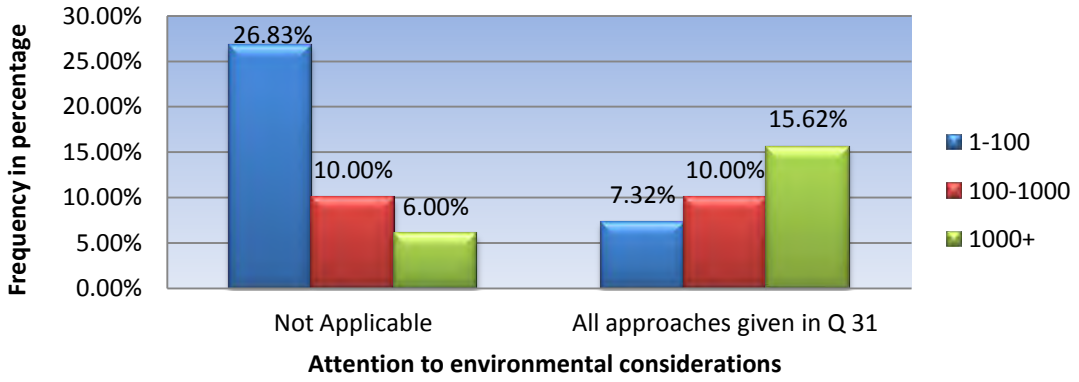


Figure A6.4: Attention to environmental considerations based on the organisations' turnover sub-classification analysis (Author)

Q32- all agree that in-house training comes first and there is no other clear consensus. It is noticeable that larger organisations (100-1000 and 1000+) pay more efforts/attentions to social considerations in general (and particularly for safety programmes) than small ones. That is clear from comparing the proportion of responses received by each approach across the three groups, the amount of respondents who selected the 'All' option in each group, and also from the amount of respondents who selected the 'Non applicable' option. However, when it comes to establishing a lean culture, it appears that turnover makes a slight difference (range from about 14.29% to 20%).

Q33- it is clear that all agree on top four (improving client satisfaction, improving quality, increasing profit, and keeping up to date). However, medium organisations prioritised the quality of their outputs (figured the 1st on top) to improving client satisfaction which figured 3rd, on contrast to small and large organisations.

Q34- all figure B3 on top. No other consensus in modal responses otherwise. Large organisations rank the procurement and contractual barrier (B2) as 5th, but it decreased gradually as turnover decreases. Small organisations (100-1000) rank B1 as 3rd but Larger organisations rank it significantly lower. A similar case occurs with B9. On contrast Larger organisations (1-100 and 1000+) rank B4 as 2nd but small organisations rank it two levels lower. These relations are shown in Figure A6.5.

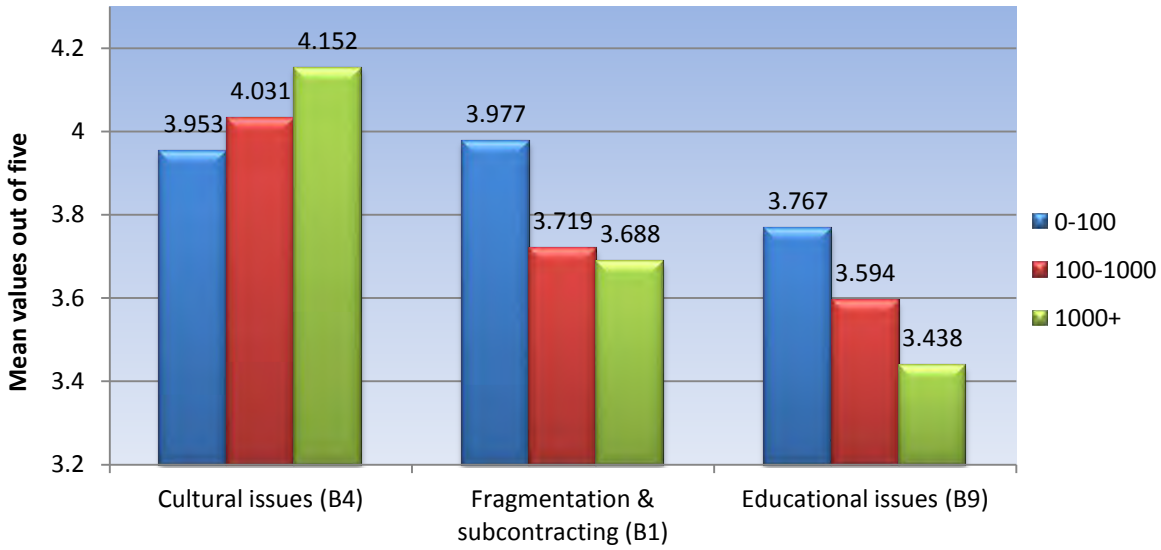


Figure A6.5: The relation between the turnover of organisations in Million sterling and cultural, fragmentation & subcontracting, and educational barriers (Author)

Q35- it appears that 37% of the respondents who belong to large organisations answered 'Yes' to questions 35 and were able to identify other barriers from their view, while only 13% and 14% of those who belong to small and medium organisations respectively provided a 'Yes' answer.

Q36- it is clear that respondents who belong to medium organisations were the most willing (53.12%), followed by those who belong to large organisations (45.16%), and then those who belong to small organisations (31.82%).

APPENDIX 7: ORGANISATIONS' SIZE CLASSIFICATION RESULTS & ANALYSIS

I. Organisation Size Sub-Classification Results & Analysis

Table A7.1: Organisation Size Sub-Classification Results and Analysis (Author)

Q. No	Organisations with less than 500 employees	Organisations with more than 500 employees
10	• Yes= 65.38%	• Yes= 66.13%
11	• Mode= 1 • Median=1 (Traditional) • Mean= 1.6	• Mode= 1 • Median= 3 (Leading) • Mean=2.58
12	• Mode= 3 • Median= 3 (Leading) • Mean= 2.75	• Mode= 3 • Median= 3 (Leading) • Mean= 2.79
13	• Mode= 1 • Median= 2 (Learning) • Mean= 2.12	• Mode= 1 • Median= 2 (Learning) • Mean= 2.56
14	• Mode= 1 • Median= 1 (Traditional) • Mean= 1.94	• Mode= 1 • Median= 2 (Learning) • Mean= 2.4
15	1. Long-Term Contractual Agreements= 56.86% 2. Document Management System= 54.9% 3. Collaborative Planning= 41.18% 4. Cross-functional teams= 31.37% 5. Project information Systems= 29.41% 6. IPD= 15.69% 7. LPDS= 11.76% 8. All= 9.8% 9. Other=3%	1. Long-Term Contractual Agreements= 76.27% 2. Document management Systems= 69.49% 3. Cross functional teams= 61.02% 4. Collaborative Planning= 44.76% 5. IPD= 47.46% 6. Project Information systems= 44.07% 7. LPDS= 25.42% 8. All= 22.03% 9. Other= 10%
16	Statements they should disagree/strongly disagree with: 1) 67.3% 2) 76.92% 5) 32.69% Statements they should agree/strongly agree with: 3) 65.38%	Statements they should disagree/strongly disagree with: 1) 76.27% 2) 86.44% 5) 33.89% Statements they should agree/strongly agree with: 3) 69.49%

	4) 59.61% 6) 23.08% 7) 30.77% 8) 86.28% 9) 74.51% 10) 57.69% 11) 78.85% *8 correct out of 11* *Average score= 59.37%*	4) 59.32% 6) 32.2% 7) 39.66% 8) 94.92% 9) 64.4% 10) 51.72% 11) 81.35% 8 correct out of 11 Average score= 62.69%
17	1. Workplace organisation= 57.14% 2. Standardised work= 57.14% 3. Problem solving= 46.94% 4. Collaborative Planning= 44.9% 5. Data Analysis= 42.86% 6. Process mapping= 40.82% 7. Visual management= 38.78% 8. Work sequence analysis= 30.61% 9. None= 12.24% 10. All= 10.2% 11. Other= 6%	1. Collaborative Planning= 54.24% 2. Data Analysis= 52.54% 3. Workplace organisation= 49.15% 4. Problem solving= 47.46% 5. Work sequence analysis= 45.76% 6. Visual management= 45.76% 7. Standardised work= 44.07% 8. Process mapping= 37.29% 9. All= 23.73% 10. None= 8.47% 11. Other= 8%
18	1. CPM= 48% 2. Look ahead planning= 42% 3. PCP tools= 30% 4. N/A= 24% 5. Workflow PM= 24% 6. Constraint analysis= 18% 7. LPS= 16% 8. Other= 12% 9. RPS= 8%	1. CPM= 75.86% 2. PCP tools= 55.17% 3. Look ahead planning= 51.72% 4. Constraint analysis= 32.76% 5. Workflow PM= 22.41%% 6. LPS= 22.41% 7. RPS= 12.07% 8. N/A= 12.07% 9. Other= 10%
19	1. None= 54% 2. PDCA= 30% 3. Prefabrication= 16% 4. Other= 12% 5. First Run studies= 10%	1. PDCA= 46.55% 2. None= 34.48% 3. Prefabrication strategies= 25.86% 4. First Run studies= 13.79% 5. Other= 10%
20	1. N/A= 59.18% 2. Visual Management= 22.45% 3. LPS= 16.33% 4. CFP= 10.2% 5. Other= 8% 6. Crane= 6.12%	1. Visual Management= 40.35% 2. N/A= 33.33% 3. CFP= 19.3% 4. LPS= 19.3% 5. Crane= 10.53% 6. Other= 10%
21	Yes= 22.45%	Yes= 66.67%
22	1. Don't know= 34.69% 2. Just-In-Time= 32.65% 3. N/A= 28.57% 4. Value stream analysis= 6.12% 5. Kanban System= 2.04%	1. Don’t know= 33.33% 2. JIT= 28.07% 3. N/A= 22.81% 4. Other= 14% 5. VS analysis= 12.28%

	6. Other= 2.04%	6. Kanban= 7.02%
23	1. N/A= 34.69% 2. None=30.61% 3. BIM= 28.57% 4. VR tools= 10.2% 5. DSM= 8.16% 6. Other= 6% 7. VDS= 4.08%	1. BIM= 41.07% 2. N/A= 19.64% 3. None= 19.64% 4. DSM= 17.86% 5. VR tools= 17.86% 6. Other= 14% 7. VDS= 10.71%
24	1. N/A= 42.86% 2. None= 28.57% 3. Concurrent design= 20.41% 4. Set based design= 16.33% 5. Other= 10%	1. N/A= 33.33% 2. None= 31.58% 3. Concurrent design= 19.3% 4. Set based design= 14.04% 5. Other= 7%
25	1. N/A= 67.35% 2. Planning= 20.41% 3. Performance measurement= 20.41% 4. Management Control= 14.29% 5. Production control= 10.2% 6. Logistics= 10.2% 7. Other= 2%	1. N/A= 55.36% 2. Planning= 28.57% 3. Production control= 21.43% 4. Management control= 21.43% 5. Logistics= 17.86% 6. Performance measurement= 17.86% 7. Other= 7%
26	• Production planning effectiveness and workflow reliability= 16.67%%	• Production planning effectiveness and workflow reliability= 14.29%
27	1. KPI= 57.14% 2. Experience of managers= 57.14% 3. Process PM= 24.49% 4. Our own metrics= 22.45% 5. LPS= 14.29% 6. Balanced scorecards= 10.2% 7. None= 10.2% 8. International benchmarking= 8.16% 9. DQI= 8.16% 10. QMPMS= 4% 11. Other= 4%	1. KPI= 89.66% 2. Experience of managers= 58.62% 3. Own metrics= 44.83% 4. Process PM= 29.31% 5. Balanced Scorecards= 24.14% 6. International benchmarking= 20.69% 7. LPS= 17.24% 8. QMPMS= 13.79% 9. DQI= 6.9% 10. Other= 5% 11. None= 1.72%
28	Mean score for 'non-financial' performance indicators (Only those achieving a score of 8 and above will be considered) 1. Safety= 9.346 2. Customer Satisfaction= 8.918 3. Quality= 8.734 4. Functionality= 7.6875 5. Team performance= 7.612 6. Productivity= 7.591 7. Planning Efficiency= 7.408	Mean score for 'non-financial' performance indicators (Only those achieving a score of 8 and above will be considered) 1. Safety= 9.637 2. Customer Satisfaction= 9.344 3. Quality= 8.793 4. Team performance= 7.965 5. Productivity= 7.965 6. Planning Efficiency= 7.775 7. Functionality= 7.741
29	1. less waste= 76.6%	1. less waste= 74.14%

	2. improved productivity= 74.47% 3. fewer defects and improved quality= 65.96% 4. reduced cost= 59.57% 5. more client satisfaction= 57.45%	2. fewer defects and improved quality= 68.97% 3. improved productivity= 67.24% 4. reduced cost= 63.79% 5. more client satisfaction and improved safety and health conditions= 55.17%
30	1. Cost and Value Management= 59.57% 2. Risk management= 57.45% 3. All= 21.28% 4. LC= 19.15% 5. SC assistance= 19.15% 6. Other= 10%	1. Cost and Value Management= 51.72% 2. Risk management= 51.72% 3. All= 29.31% 4. SC assistance= 27.59% 5. LC= 15.52% 6. Other= 3%
31	1. BREEAM= 37.5% 2. International standards= 31.25% 3. N/A= 25% 4. LC= 18.75% 5. Other= 10% 6. SC assistance= 4.17% 7. All= 4.17%	1. International standards= 64.91% 2. BREEAM= 40.35% 3. Supply Chain Assistance= 35.09% 4. All=15.79% 5. LC= 8.77% 6. N/A= 7% 7. Other= 5%
32	1. In-house training= 36.73% 2. Job knowledge and Skills scheme= 28.57% 3. Team development Programme= 28.57% 4. Community engagement= 28.57% 5. N/A= 18.37% 6. Safety programmes= 18.37% 7. Lean culture= 12.24% 8. Other= 12.24% 9. All= 6%	1. In-house training= 58.62% 2. Community engagement= 51.72% 3. Safety programmes= 41.38% 4. Job knowledge and skills scheme= 37.93% 5. Team development= 25.86% 6. Lean culture= 20.69% 7. All= 17.24% 8. Other= 8% 9. N/A= 1.72%
33	1. To improve our rate of client 2. Satisfaction= 48.89% 3. To increase our profit and /or 4. Turnover= 48.89% 5. To improve the quality of our 6. Outputs= 46.67% 7. To keep up-to-date= 26.67% 8. As a respond to the Egan's report= 15.56% 9. Other= 13% 10. We are satisfied, no need to change= 11.11% 11. When a major problem 12. Occurs= 11.11%	1. To improve our rate of client 2. Satisfaction= 58.62% 3. To increase our profit and /or 4. Turnover= 55.17% 5. To improve the quality of our 6. Outputs= 51.72% 7. To keep up to date= 41.38% 8. As a respond to the Egan's report= 17.24% 9. Other= 15% 10. When a major problem 11. Occurs= 8.62% 12. We are satisfied; No need to change= 6.9%
34	*Only barriers with a mean score of 4.0 and above will be classified as significant barriers:* Fragmentation & subcontracting= 3.961 Procurement & contracts= 3.824	*Only barriers with a mean score of 4.0 and above will be classified as significant barriers:* Fragmentation & subcontracting= 3.69 Procurement & contracts= 3.672 Lack of adequate Lean awareness &

	Lack of adequate Lean awareness & understanding= 4.275 Cultural issues= 3.961 Time & commercial pressure= 3.882 Financial issues= 3.549 Lack of top management commitment= 4.137 Design/Construction Dichotomy= 3.49 Educational issues= 3.784 Lack of process based PMS= 3.745	understanding= 4.333 Cultural issues= 4.117 Time & commercial pressure= 3.864 Financial issues= 3.417 Lack of top management commitment= 4.0 Design/Construction Dichotomy= 3.379 Educational issues= 3.5 Lack of process based PMS= 3.424
35	• Yes= 11.76%	• Yes= 28.81%
36	• Yes= 38.46%	• Yes= 48.28%

II. Organisation Size Sub-Classification In-depth Analysis

Q10- it seems that the size of organisations, in terms of number of employees, does not make any difference to the level of awareness of the LCI-UK (range 65.38% - 66.13%).

Q11- there seems to be consistency in the modal responses (Traditional), but median shows very significant variation as large organisations which have more than 500 employees obtained a median value equal to 3 (Leading) while small organisations obtained a much lower value (Traditional).

Q12- it is obvious there is very strong consistency in the responses. Mean, median, and mode values are almost the same.

Q13- there seems to be strong consistency in the modal and median responses; but large organisations (more than 500 employees) obtained a higher mean value than smaller ones (range 2.12 – 2.56). These results suggest that the size of the organisations makes a little difference to the level of lean commitment.

Q14- there is no change in modal responses, but there seems to be some variations in median responses as respondents who belong to large organisations (more than 500 employees) suggest some training, but those belonging to small organisations suggest no training. There is also noticeable difference in the mean values, as small organisations obtained a mean value equal to 1.9, but large organisations obtained a mean value equal to 2.4.

Q15- it appears that both agree on top two: long term contractual agreements and document management systems. Also both agree on bottom three: LPDS, All, and Other. However LPDS was selected by 25.42% of the respondents who belong to large organisations (more than 500 employees), while it was selected by only 11.76% of those who belong to smaller organisations. Similarly, the former put IPD as 5th (selected by 47.46% of the respondents), but the latter ranked it as 6th (only 15.69% of the respondents).

Q16- it seems that size of organisations (in terms of number of employees) makes a limited difference to the level of understanding of lean concepts and practices. Large organisations obtained a score= 62.69%, while small organisations obtained a score= 59.37%. Also, both answered 8 statements correctly.

Q17- it appears very clearly that the same relations analysed before (organisation turnover sub-classification analysis) exists exactly. The only difference is that when comparing according to size, it appears more clearly that large organisations selected the 'All' option more frequently than smaller organisations (range 10% - 23.73%).

Q18- it is obvious that LPS is used more frequently in larger organisation (in terms of turnover and number of employees) than in smaller organisations.

Q19- organisations with more than 500 employees, ranked PDCA as number one (46.55%), but it came second for organisations with less than 500 employees (30%).

Q20- it is obvious that larger organisations (more than 500 employees) use visual management much more frequently than smaller organisations. For instance, visual management was selected by 40.35% of respondents who belong to large organisations, and came 1st in ranking. On contrast, only 22.25% of the respondents who belong to smaller organisations (less than 500 employees) selected the visual management technique, and it came 2nd in their ranking. Although, small organisations ranked LPS as 3rd which is one level higher than larger organisations, they use it slightly less frequently (range 16.3% - 19.3%).

Q21- it seems that organisation size makes a very considerable difference to the amount of successful experience with principles of TQM, SCM and CE, as larger organisations which includes more than 500 employees have or have had much more successful experience with the management concepts specified in this question (about three times more) than smaller organisations which have less than 500 employees (range 22.45% - 66.67%).

Q22- it can be seen that there is no change in modal response between both, and very little difference to the awareness of the JIT supply techniques (range 32% to 28%).

Q23- it appears that large organisations (more than 500 employees) ranked BIM as number 1 but small organisations put it as 3rd (range 28.57% - 41%).

Q24- it appears that in both cases, the 'None' and 'Not Applicable' options always figured in the top two modal responses. No other consensus otherwise.

Q25- One significant observation is that LPS is used for production control in larger organisations more frequently than in smaller ones. For instance, production control ranked 3rd in the modal response of organisations with more than 500 employees (21.43%), but ranked 5th in the modal response of organisations with less than 500 employees (only 10.2%).

Q26- By referring to the organisation size sub-classification analysis, analysis, it appears that the size of organisations, in terms of number of employees, makes 'very little' difference to the awareness/understanding of the function of the PPC value in LPS (range 14% - 16).

Q27- Both agree on top two (KPI & experience of managers) and bottom three (DQI, Other, None). It also appears that larger organisations have a higher tendency to establish their own metrics which is consistent with their business strategy and includes leading indicators aiming to provide them with early warnings, than small ones (range 22% - 44%).

Q28- Both agree on top 3 (safety, client/customer satisfaction, and then quality), There is no obvious consensus otherwise, as each group ranks the other performance measures in different order.

Q29- it appears that large organisations that have a 1000+ turnover and more than 500 employees are the only two groups aware of the 'improved safety and health conditions' benefit that could be achieved from applying lean principles to construction. In both cases, it achieved a weighting score of about 57%.

Q30- there seems to be consistency in the modal responses. Both agreed on top three (cost & value management, risk management & mitigation, and All), and also in all cases 'Other' figured in bottom. Although LC came in a different order in each case but still no much difference (range from 19.15% for small organisations to 15.5% for large organisations), but it is clear that organisations with more than 500 employees (large organisations) are more aware of the importance of supply-chain assistance than smaller ones (range 19.15% - 27.59%).

Q31- 25% of the respondents who belong to organisations with less than 500 employees went for the 'Not applicable' option while only 7% of those who belong to larger organisations went for the same option. Furthermore, only 4.17% of the small organisations selected the 'All' option and it came at the bottom of their model response order, while on contract 15.79% of the larger organisations selected the 'All' option and it ranked 4th in their modal response order.

Q32- it appears that larger organisations (with more than 500 employees) are more interested into or aware to the importance of establishing a lean culture than smaller organisations. That is obvious from the amount of respondents who selected the 'Lean Culture' option. The latter was selected by 20.69% of the respondents who belong to organisations with more than 500 employees (large organisations), but only selected b 12.24% of those who belong to organisations with less than 500 employees (small organisations). Similarly the 'All' option was selected by only 6% of the responses who belong to small organisations and it figured at the bottom of their list, but selected by 17.24% of the respondents who belong to large organisations and it ranked 7th.

Q33- it is obvious that there is a consistency in their responses, as all agree on top 6.

Q34- both agree that B1 should come first. There is no consistency in modal responses otherwise. Small organisations rank B7 as 2nd (mean value= 4.137) while large organisations rank it 3rd (mean value= 4.0). On the other hand, the latter rank cultural issues as 2nd (mean value= 4.117), while small organisations rank it 3rd (mean value= 3.96).

Q35- it is clear that 28.81% of the respondents who belong to large organisations (more than 500 employees) provided a 'Yes' answer and were able to identify other barriers to the implementation of LC, while only 11.76% of those who belong to small organisations provided a 'Yes' option.

Q36- the results show that those who belong to large organisations which has more than 500 employees were slightly more willing than those who belong to smaller organisations (range 48% - 38%).

APPENDIX 8: ORGANISATIONS' MAJOR CLIENT CLASSIFICATION RESULTS & ANALYSIS

I. Organisation Major client Sub-Classification Results & Analysis

Table A8.1: Major Client Sub-Classification Results and Analysis (Author)

Q. No	Private Individuals and Organisations	Public Organisations
10	• Yes= 68%	• Yes= 58.8%
11	• Mode= 1 • Median= 1 (Traditional) • Mean= 1.75	• Mode= 1 • Median= 2 (Learning) • Mean= 2.35
12	• Mode= 3 • Median= 3 (Leading) • Mean= 2.54	• Mode= 2 • Median= 3 (Leading) • Mean= 2.76
13	• Mode= 1 • Median= 2 (Learning) • Mean= 2.43	• Mode= 1 • Median= 2 (Learning) • Mean= 2.64
14	• Mode=1 • Median= 1 (Traditional) • Mean= 2.04	• Mode= 2 • Median= 2 (Learning) • Mean= 2.47
15	1. Document Management Systems= 66.67% 2. Long-Term Contractual Agreements= 50% 3. Project Information Systems= 41.67% 4. Collaborative planning schedules= 41.67% 5. Cross functional teams= 33.33% 6. IPD= 20.83% 7. LPDS= 20.83% 8. All= 4.17% 9. Other= 0%	1. Long-Term Contractual Agreements= 70.59% 2. Cross-Functional Teams= 47% 3. Document Management Systems= 47% 4. Project Information Systems= 29.41% 5. Collaborative Planning Schedules= 29.41% 6. IPD= 23.53% 7. LPDS= 23.53% 8. All= 23.53% 9. Other= 5%
16	Statements they should disagree/strongly disagree with: 1) 76% 2) 84% 5) 40% Statements they should agree/strongly agree with: 3) 80% 4) 64% 6) 20%	Statements they should disagree/strongly disagree with: 1) 70.59% 2) 88.24% 5) 29.41% Statements they should agree/strongly agree with: 3) 82.35% 4) 70.59% 6) 29.41%

	7) 44% 8) 92% 9) 83.34% 10) 72% 11) 92% 8 correct out of 11 *Average score= 67.94%*	7) 29.41% 8) 100% 9) 70.59% 10) 76.47% 11) 88.23% 8 correct out of 11 *Average score= 66.84%*
17	1. Workplace organisation= 60.87% 2. Collaborative Planning= 52.17% 3. Standardised work= 52.17% 4. Problem solving= 52.17% 5. Data Analysis= 47.83% 6. Visual management= 47.83% 7. Work sequence analysis= 34.78% 8. Process mapping= 30.43% 9. None= 17.39% 10. All=8.7% 11. Other= 0%	1. Data Analysis= 47.06% 2. Visual management= 41.18% 3. Workplace organisation= 41.18% 4. Process mapping= 35.29% 5. Problem solving= 35.29% 6. Collaborative Planning= 29.41% 7. Standardised work= 29.41% 8. All= 29.41% 9. Work sequence analysis= 23.53% 10. None= 17.69% 11. Other= 11%
18	1. CPM= 52.17% 2. Look ahead planning= 34.78% 3. Workflow PM= 30.43% 4. PCP tools= 30.43% 5. N/A= 26.09% 6. LPS= 17.39% 7. Constraint analysis= 17.39% 8. Other= 8% 9. RPS= 8%	1. CPM= 58.82% 2. Look ahead= 52.94% 3. PCP tools= 41.18% 4. LPS= 17.65% 5. N/A= 11.76% 6. Workflow PM= 11.76% 7. Constraint analysis= 11.76% 8. Other= 11% 9. RPS= 5.88%
19	1. None= 50% 2. PDCA= 33.33% 3. Prefabrication= 20.83% 4. FRS= 12.5% 5. Other= 8%	1. None= 41.18% 2. PDCA= 41.18% 3. Prefabrication= 11.76% 4. Other= 11.76% 5. FRS= 5%
20	1. N/A= 54.55% 2. VM= 31.82% 3. CFP= 13.84% 4. Other= 13% 5. LPS= 9.09% 6. Crane= 4.55%	1. N/A= 47% 2. VM= 35.29% 3. CFP= 17.65% 4. LPS= 17.65% 5. Crane= 0% 6. Other= 0%
21	• Yes= 26%	• Yes= 35.29%
22	1. N/A= 39.13% 2. JIT= 26.09% 3. Don't know= 21.74% 4. VS analysis= 8.88% 5. Kanban= 8.88% 6. Other= 8.88%	1. Don't know= 53% 2. JIT= 29.41% 3. VS analysis= 11.76% 4. N/A= 5.88% 5. Kanban= 5.88% 6. Other= 5.88%
23	1. N/A= 34..78%	1. None= 58.82%

	2. BIM= 26.09% 3. None= 21.74% 4. VR tools= 17.39% 5. Other= 13% 6. VDS= 8.7% 7. DSM= 4.35%	2. BIM= 17.65% 3. N/A= 11.76% 4. Other= 11% 5. DSM= 6% 6. VR tools= 6% 7. VDS= 0%
24	1. N/A= 47.83% 2. None= 21.74% 3. Concurrent design= 13% 4. Set based design= 13% 5. Other= 8%	1. None= 41.18% 2. N/A= 29.41% 3. Concurrent design= 23.53% 4. Other= 5% 5. Set based design= 0%
25	1. N/A= 73.91% 2. Planning= 21.74% 3. Logistics= 13% 4. Performance measurement= 13% 5. Production control= 8.7% 6. Management control= 8.7% 7. Other= 0%	1. N/A= 58.82% 2. Performance measurement= 23.53% 3. Planning= 17.65% 4. Management control= 17.65% 5. Production control= 11.76% 6. Other= 11.76% 7. Logistics= 6%
26	• measures production planning effectiveness and workflow reliability= 18.18%	• measures production planning effectiveness and workflow reliability= 25%
27	1. Experience of managers= 69.57% 2. KPI= 65.22% 3. Own metrics= 21.74% 4. Process PM= 17.39% 5. International benchmarking= 13% 6. LPS= 13% 7. Balanced Scorecards= 8.7% 8. QMPMS= 8.7% 9. None= 8.7% 10. Other= 0%	1. KPI= 94.12% 2. own metrics= 58.82% 3. Experience of managers= 58.82% 4. Process PM= 29.41% 5. International benchmarking= 23.53% 6. Balanced Scorecards= 23.53% 7. LPS= 17.65% 8. QMPMS= 6% 9. None= 0% 10. Other= 0%
28	*Mean score for 'non-financial' performance indicators (Only those achieving a score of 8 and above will be considered)* 1. Safety= 9.521 2. Customer Satisfaction= 9.174 3. Quality= 8.869 4. Functionality= 7.608 5. Planning Efficiency= 7.562 6. Productivity= 7.521 7. Team performance= 7.434	*Mean score for 'non-financial' performance indicators (Only those achieving a score of 8 and above will be considered)* 1. Safety= 9.625 2. Customer Satisfaction= 9.25 3. Quality= 8.875 4. Functionality= 8.0 5. Productivity= 8.0 6. Team performance= 7.9375 7. Planning Efficiency= 7.5625
29	1. less waste= 81.82% 2. improved productivity= 72.73% 3. fewer defects and improved quality= 72.73% 4. more client satisfaction 68.18% 5. reduced cost= 68.18%	1. Less waste= 88.24% 2. Improved productivity= 76.47% 3. fewer defects and improved quality= 70.59% 4. reduced cost= 70.59% 5. more client satisfaction= 58.82%

30	1. Risk management and mitigation= 60.87% 2. Cost and Value Management= 60.87% 3. LC= 26% 4. SC assistance= 26% 5. All= 26% 6. Other= 0%	1. Risk management= 62.5% 2. Cost and Value Management= 43.75% 3. All= 25% 4. LC= 18.75% 5. SC assistance= 12.5% 6. Other= 12%
31	1. N/A= 31.82% 2. International standards= 31.82% 3. BREEAM= 18.18% 4. SC assistance= 13.64% 5. LC= 13.64% 6. Other= 13% 7. All= 4.55%	1. International standards= 58.82% 2. BREEAM= 47% 3. SC assistance= 17.65% 4. LC= 11.76% 5. Other= 11% 6. All= 5.88% 7. N/A= 0%
32	1. Community engagement= 47.83% 2. In-house training= 34.78% 3. Job knowledge and Skills scheme= 34.78% 4. Safety programmes= 30.43% 5. N/A= 21.74% 6. Lean culture= 21.74% 7. Team development= 21.74% 8. All= 4.35% 9. Other= 4%	1. In-house training= 41.18% 2. Safety programmes= 41.18% 3. Community engagement= 41.18% 4. Job knowledge and skills scheme= 35.29% 5. Team development= 29.41% 6. Other= 17% 7. Lean culture= 11.76% 8. Other= 17% 9. All= 11.76%
33	1. To improve the quality of our outputs= 59% 2. To improve our rate of client Satisfaction= 59% 3. To increase our profit= 54.55% 4. To keep up-to-date= 31.82% 5. As a respond to the Egan's report= 27.27% 6. When a major problem Occurs= 13.64% 7. Other= 4% 8. We are satisfied, no need to change= 4%	1. To improve our rate of client satisfaction= 52.94% 2. To improve the quality of our outputs= 47% 3. To increase our profit= 17% 4. To keep up-to-date= 29.41% 5. Other= 17% 6. As a respond to the Egan's report= 5.88% 7. We are satisfied, no need to change= 5.88% 8. When a major problem Occurs= 0%
34	*Only barriers with a mean score of 4.0 and above will be classified as significant barriers*: Fragmentation & subcontracting= 3.96 Procurement & contracts= 3.96 Lack of adequate Lean awareness & understanding= 4.6 Cultural issues= 4.08 Time & commercial pressure= 3.96 Financial issues= 3.56 Lack of top management commitment= 4.44 Design/Construction Dichotomy= 3.5 Educational issues=3.88 Lack of process based PMS= 3.8	Only barriers with a mean score of 4.0 and above will be classified as significant barriers: Fragmentation & subcontracting= 4.235 Procurement & contracts= 3.588 Lack of adequate Lean awareness & understanding= 4.294 Cultural issues= 4.235 Time & commercial pressure= 3.529 Financial issues= 3.118 Lack of top management commitment= 3.824 Design/Construction Dichotomy= 2.941 Educational issues= 3.294 Lack of process based PMS= 3.588

35	• Yes= 19.23%	• Yes= 17.65%
36	• Yes= 46.15%	• Yes= 35.29%

II. Organisation Major Client Sub-Classification In-depth Analysis

Q10- it appears that respondents who deal with private organisations are slightly more aware of the LCI-UK than those who deal with public organisations (range 68% - 58.8% respectively).

Q11- it appears that there is no change in modal responses; but there is a noticeable change in the median responses, as those who deal with public organisations provided more optimistic responses.

Q12- it is obvious that respondents who deal with private organisations provided more consistent responses than those who deal with private organisations. Both achieved the same median values (Leading), but the latter obtained a lower modal value than the former.

Q13- there seems to be strong consistency in the responses.

Q14- it appears that there is no consistency in the responses, as respondents who deal with private organisations provided low modal and median responses suggesting that their leadership team have not been through any formal training into lean thinking, while respondents who deal with public provided more optimistic responses suggesting some training.

Q15- it appears that both agree on bottom four, namely: IPD, LPDS, All, and Other. However, respondents who deal with private organisations put document management systems on top (1st), while those who deal with public organisations ranked it as 3rd and

placed long term contractual agreements as their 1st. Alternatively, the latter put cross functional teams as number 2 but the former ranked it significantly lower.

Q16- it appears that the nature of the client does not make a difference to the level of awareness/understanding of lean concepts and practices. Both answered 8 statements correctly out of 11 and there have not been much difference in their scores (private clients score= 67.94% while private organisations score= 66.84%).

Q17- it appears that both agree on the bottom (Other) but no other consensus otherwise. Private organisations put workplace organisation as number one, while public organisations ranked it noticeably lower (41.18%). Also, the latter put data analysis as 1st but the former ranked it significantly lower. One important observation is that almost 30% of the respondents who deal with public organisations selected the 'All' option and ranked it as 8th, while only 8.7% of those who deal with private organisations selected it and they ranked it significantly lower.

Q18- both agree on top two (CPM and look ahead planning), and also agree on bottom three (constraint analysis, other, and RPS). However, private organisations put workflow production management third but public ones ranked it significantly lower. Also, although the latter ranked LPS as 4th while the former ranked it as 6th, it was selected by about 17% of the respondents who belong to each.

Q19- there seems to be no change in modal responses.

Q20- both agree on top three (not applicable, visual management, and CFP). Public organisations ranked LPS as 4th (selected by 17.65% of the respondents), while private organisations put it lower (selected by only 9% of the respondents).

Q21- it appears that those who deal with public organisations are slightly more aware of the management concepts (TQM, SCM and CE), as they achieved a score of 35.29%, while those who deal with private individuals and organisations (achieved a score of 25%).

Q22- it can be seen that there is no change in modal response between the private and public sectors, and very little difference to the awareness of the supply techniques (range 26% - 29%). Similarly when comparing between organisations according to their size (range 32% to 28%).

Q23- there seems to be significant variations in the modal responses as public organisations put 'None' 1st while private organisations ranked it as 3rd (range 21.74% - 58.82%). Alternatively, both ranked BIM as 2nd; however, it was selected by 26.09% of the respondents who belong to private organisations but was selected by 17.65% of the respondents who belong to public organisations.

Q24- in both cases, the 'None' and 'Not Applicable' options always figured in the top two modal responses. No other consensus otherwise.

Q25- it appears that organisations which deal with the public sector focus their attentions on using LPS for performance measurement and organisational learning, as opposed to those who deal with private organisations where LPS is mostly used for planning and scheduling.

Q26- public organisations are slight more aware of the use of the PPC value within LP than private organisations (range from 18% for the latter to 25% for the former)

Q27- Both agree on the bottom 4 techniques (QMPMS, None, DQIs, and Other). Otherwise, it is clear that private organisations rely mostly on the experience of managers, while public organisations prioritise results based KPIs and establishing leading indicators to using the experience of their managers.

Q28- Both agree on top 3 (safety, client/customer satisfaction, and then quality).

Q29- there seems to be strong consistency in the modal responses, as both agree on top 5.

Q30- there does not seem to be much difference between respondents who deal with private or public organisations. However, the results show that supply-chain assistance was selected by 26% of the respondents who deal with private organisations (it was ranked as 4^{th}), while it was selected by only 12.5% of those who deal with public organisations (and it was ranked as 5^{th}).

Q31- it is obvious that public organisations pay more attention to environmental considerations. That is evident from the amount of respondents who belong to private organisations that selected the 'Not applicable option' (31.82%); while on contrast, none at all of those who belong to public organisations selected that option. When it comes to LC and supply-chain assistance, there is a little change in modal response order but almost used as frequently as each other (range 13.64% - 11.76% and 13.64% - 17.65% correspondingly).

Q32- it seems that both agree on the top four but with different orders. However, it is also noticeable that public organisations pay more attention to safety programmes than private organisations, while on contrast the latter are more interested into community engagement than public organisations. Also, 21.74% of respondents who belong to private organisations selected the 'Lean culture' approach as a means for achieving social considerations, while only 11.76% of those who belong to public organisations went for the same option. On contrast only 4.35% of the respondents who belong to private organisations selected the 'All' option while 11.76% of those who belong to public organisations went for the same option. One very significant observation is that in case of public organisations, the same amount of respondents selected the 'Lean Culture and 'All options (11.76%); but in case of private organisations there was no consistency (21.74% for 'Lean culture' and only 4.35% for 'All'). Here it seems important to question the private organisations' understanding to the term 'Lean Culture', as a 'Lean Culture' should be at least or almost as equal to 'All'. There should not be a big gap between the proportions of responses given to each.

Q33- it appears that both agree on the top three. However, organisations which deal with the private individuals and organisations prioritise the quality of their outputs to client satisfaction, as opposed to those who deal with public organisations. It is also noticeable 54.55% of the respondents who deal with private organisations agree that increasing profit could be one of the major reasons that could pull their organisations to the lean journey, while only 17% of those who deal with public organisations agreed to that, and it ranked 4th based on their modal response sequence. On contrast none of the latter agreed that the occurrence of a major problem could be one of the reasons for going on the lean journey, while about 14% of the respondents who deal with private organisations agreed with that.

Q34- it appears that both agree that B1 should figure on top. However, private organisations rank B7 as 2nd from top (obtained a mean value= 4.44), but public organisations rank it two levels lower (mean value= 3.824). Please see Table A8.2 below.

Table A8.2: The mean values of barriers identified based on the major client sub-classification analysis (Author)

ID	Private Organisations	Public organisations
B1	Fragmentation & subcontracting= 3.96	Fragmentation & subcontracting= 4.235
B2	Procurement & contracts= 3.96	Procurement & contracts= 3.588
B3	Lack of adequate Lean awareness & understanding= 4.6	Lack of adequate Lean awareness & understanding= 4.294
B4	Cultural issues= 4.08	Cultural issues= 4.235
B5	Time & commercial pressure= 3.96	Time & commercial pressure= 3.529
B6	Financial issues= 3.56	Financial issues= 3.118
B7	Lack of top management commitment= 4.44	Lack of top management commitment= 3.824
B8	Design/Construction Dichotomy= 3.5	Design/Construction Dichotomy= 2.941
B9	Educational issues=3.88	Educational issues= 3.294
B10	Lack of process based PMS= 3.8	Lack of process based PMS= 3.588

Q35- it appears that almost the same proportion of respondents of each group provided a 'Yes' answer to question 35 (range 19% - 17%).

Q36- it appears that those which deal with private organisations were slightly more willing to take part in the interviews (range 46% - 35%).

APPENDIX 9: YEARS OF EXPERIENCE CLASSIFICATION RESULTS & ANALYSIS

I. Years of Experience Sub-Classification Results and Analysis

Table A9.1: Years of Experience Sub-Classification Results and Analysis (Author)

Q. No	0-10 Years of Experience	10-20 Years of Experience	20+ Years of Experience
10	• 47.22% Yes	• 75.76 % Yes	• 72.73 % Yes
11	• Mode= 1 • Median= 1 (Traditional) • Mean= 2.138	• Mode= 1 • Median= 1 (Traditional) • Mean= 2.09	• Mode= 1 • Median= 1 (Traditional) • Mean= 2.209
12	• Mode= 3 • Median= 3 (Leading) • Mean= 2.78	• Mode= 3 • Median= 3 (Leading) • Mean= 2.65	• Mode= 3 • Median= 3 (Leading) • Mean= 2.837
13	• Mode= 1 • Median= 2 (Learning) • Mean= 2.39	• Mode= 1 • Median= 2 (Learning) • Mean= 2.35	• Mode= 1 • Median= 2 (Learning) • Mean= 2.634
14	• Mode= 1 • Median= 1 (Traditional) • Mean= 2.05	• Mode= 1 • Median= 2 (Learning) • Mean= 2.096	• Mode= 1 • Median= 2 (Learning) • Mean= 2.357
15	1. Long term Contractual Arrangement= 62.86% 2. Document Management systems= 57.14% 3. Cross-Functional Teams= 37.14% 4. Collaborative Planning= 37.14% 5. Project Information Systems= 25.71% 6. IPD= 25.71% 7. LPDS= 20% 8. All=11.43% 9. Other= 5%	1. Long term Contractual Arrangement= 81.25% 2. Document Management Systems= 65.62% 3. Project Information Systems= 46.88% 4. Cross-Functional Teams=40.62% 5. Collaborative Planning= 40.62% 6. IPD= 28.12% 7. LPDS= 15.62% 8. All= 15.62% 9. Other= 9%	1. Document Management Systems= 64.29% 2. Long-Term Contractual Agreements= 61.9% 3. Cross-Functional Teams= 61.9% 4. Collaborative planning= 52.38% 5. IPD= 40.48% 6. Project Information Systems= 40.48% 7. LPDS= 21.43% 8. All= 21.43% 9. Other= 7%
16	*Statements they should disagree/strongly disagree with:* 1) 71.43% 2) 82.86% 5) 45.72%	Statements they should disagree/strongly disagree with: 1) 78.12% 2) 78.13% 5) 37.5%	Statements they should disagree/strongly disagree with: 1) 67.44% 2) 83.72% 5) 32.56%

	Statements they should agree/strongly agree with: 3) 62.86% 4) 60% 6) 25.71% 7) 23.53% 8) 94.29% 9) 65.71% 10) 47.06% 11) 71.43% 7 correct out of 11 *Average score= 59.145%*	Statements they should agree/strongly agree with: 3) 68.74% 4) 65.62% 6) 34.38% 7) 37.5% 8) 87.5% 9) 70.96% 10) 56.24% 11) 87.5% 8 correct out of 11 *Average score= 63.835%*	Statements they should agree/strongly agree with: 3) 69.76% 4) 53.49% 6) 25.58% 7) 44.19% 8) 90.48% 9) 69.77% 10) 60.46% 11) 81.4% 8 correct out of 11 *Average score= 61.71%*
17	1. Standardised work= 55.88% 2. Workplace organisation= 52.94% 3. Problem solving= 52.94% 4. Collaborative planning= 47.06% 5. Data analysis= 47.06% 6. Visual management= 47.06% 7. Process mapping= 38.24% 8. Work sequence analysis= 35.29% 9. All= 20.59% 10. None= 11.76% 11. Other= 5%	1. Collaborative Planning= 50% 2. Standardised work= 46.88% 3. Work sequence analysis= 43.75% 4. Workplace organisation= 43.75% 5. Process mapping= 43.75% 6. Data Analysis= 37.5% 7. Problem solving= 37.5% 8. Visual management= 31.25% 9. None= 15.62% 10. All= 9.38% 11. Other= 9%	1. Data Analysis= 58.54% 2. Workplace organisation= 58.54% 3. Collaborative Planning= 51.22% 4. Problem solving= 51.22% 5. Visual management= 48.78% 6. Standardised work= 46.34% 7. Work sequence analysis= 36.59% 8. Process mapping= 36.59% 9. All= 21.95% 10. Other= 7% 11. None= 5%
18	1. CPM= 58.82% 2. Look ahead planning= 47.06% 3. PCP tools= 38.24% 4. Workflow PM= 23.53% 5. Constraint analysis= 23.53% 6. N/A= 17.65% 7. RPS= 11.76% 8. Other= 11% 9. LPS= 8.82%	1. CPM= 64.52% 2. Look ahead planning= 41.94% 3. PCP tools= 38.71% 4. Not applicable= 19.35% 5. Workflow PM= 19.35% 6. LPS= 19.35% 7. Constraint analysis= 19.35% 8. Other= 6% 9. RPS= 3.25%	1. CPM= 66.67% 2. Look ahead Planning= 50% 3. PCP tools= 50% 4. Constraint analysis= 33.33% 5. LPS=28.57% 6. Workflow PM= 26.19% 7. N/A= 16.67% 8. RSPS= 14%% 9. Other= 14%
19	1. None= 47.06% 2. PDCA= 41.18% 3. Prefabrication= 20.59% 4. First Run Studies= 11.76% 5. Other= 8%	1. None= 46.88% 2. PDCA= 31.25% 3. Other= 18% 4. Prefabrication= 15.62% 5. First Run Studies= 12.5%	1. PDCA= 41.46% 2. None= 39.02% 3. Prefabrication= 26.83% 4. FRS= 12.2% 5. Other= 7%
20	1. Not Applicable= 47.06%	1. Not Applicable= 50%	1. N/A= 39.02%

	2. VM= 35.29% 3. CFP=23.53% 4. LPS= 11.56% 5. Crane= 11.56% 6. Other= 5%	2. VM= 23.33% 3. LPS= 16.67% 4. Other= 13% 5. CFP= 10% 6. Crane= 6.67%	2. VM= 36.59% 3. LPS= 24.39% 4. CFP= 12.2% 5. Other= 9% 6. Crane= 7.32%
21	• 39.39% Yes	• 61.29% Yes	• 41.46%% Yes
22	1. Don't know= 42.42% 2. JIT= 33.33% 3. N/A= 18.18% 4. Value stream analysis= 6% 5. Other= 6% 6. Kanban System= 0%	1. Don't Know= 41.94% 2. N/A= 35.48% 3. JIT= 12.9% 4. Other=12% 5. Value stream analysis= 3.23% 6. Kanban= 3.23%	1. JIT= 41.46% 2. N/A= 24.39% 3. Don't know= 19.51% 4. VS analysis= 17.07% 5. Kanban= 9.76% 6. Other= 7%
23	1. BIM= 32.35% 2. None= 29.41% 3. N/A= 26.47% 4. Design structure matrix= 14.71% 5. Other= 11% 6. Virtual reality tools= 8.82 7. Virtual design studio= 5.88%	1. BIM= 43.33% 2. N/A= 30% 3. Design structure matrix= 13.33% 4. Virtual reality tools= 13.33% 5. None= 13.33% 6. Other= 13% 7. Virtual design studios= 6.67%	1. BIM= 30% 2. None= 30% 3. N/A= 25% 4. VR tools= 17.5% 5. DSM= 12.5% 6. VDS= 10% 7. Other= 7%
24	1. N/A= 47.06% 2. Set-based design= 20.59% 3. None= 20.59% 4. Concurrent design= 14.71% 5. Other= 8%	1. N.A= 40% 2. None= 33.33% 3. Concurrent design= 16.67% 4. Set-based design= 13.33% 5. Other= 13%	1. None= 34.15% 2. N/A= 29.27% 3. Concurrent design= 26.83%% 4. Set-based design= 12.2% 5. Other= 4%
25	1. N/A= 57.58% 2. Planning as an activity schedule= 21.21% 3. Management control= 21.21% 4. Performance measurement= 15.15% 5. Production control= 12.12% 6. Logistics= 9.09% 7. Other= 6%	1. N/A= 70% 2. Planning as an activity schedule= 16.67% 3. Production control= 16.67% 4. Logistics= 16.67% 5. Management Control= 13.33% 6. Performance measurement= 10% 7. Other= 3%	1. N/A= 56.1% 2. Planning= 34.15% 3. Performance measurement= 29.27% 4. Production control= 19.51% 5. Management Control= 19.51% 6. Logistics= 17.07% 7. Other= 4%
26	• 15.15% (measures production planning effectiveness and workflow reliability)	• 3.33% (measures production planning effectiveness and workflow reliability)	• 25% (measures production planning effectiveness and workflow Reliability)
27	1. KPI= 64.71% 2. Experience of managers= 61.76% 3. Process performance	1. KPI= 77.42% 2. Experience of managers= 51.61% 3. Own metrics= 25.81%	1. KPI= 80.49% 2. Experience of managers= 58.54% 3. Own metrics= 48. 78%

	measures= 29.41% 4. Own metrics= 26.47% 5. International benchmarking= 17.65% 6. Balanced Score cards= 11.76% 7. LPS= 8.82% 8. DQI= 8.82% 9. QMPMS= 5.88% 10. None= 5.88% 11. Other= 5%	4. Process Performance measures= 19.35% 5. Balanced score cards= 16.13% 6. LPS= 12.9% 7. International benchmarking= 9.68% 8. None= 9.68% 9. QMPMS= 6.45% 10. DQI= 3% 11. Other= 3%	4. Process PM= 31.71%% 5. LPS= 24.39% 6. Balanced Scorecards= 24.39% 7. International benchmarking= 17.07% 8. QMPMS= 14.63% 9. DQI= 9.76% 10. Other= 4% 11. None= 2.44%
28	Mean score for 'non-financial' performance indicators (Only those achieving a score of 8 and above will be considered) 1. Safety= 9.47 2. Customer Satisfaction= 9.11 3. Quality= 8.941 4. Functionality= 8.242 5. Productivity= 8.117 6. Team performance= 7.882 7. Planning Efficiency= 7.823	Mean score for 'non-financial' performance indicators (Only those achieving a score of 8 and above will be considered) 1. Safety= 9.129 2. Customer Satisfaction= 9.193 3. Quality= 8.451 4. Productivity= 8.064 5. Functionality= 8.032 6. Team performance= 8.032 7. Planning Efficiency= 7.806	Mean score for 'non-financial' performance indicators (Only those achieving a score of 8 and above will be considered) 1. Safety= 9.804 2. Customer Satisfaction= 9.195 3. Quality= 8.902 4. Team performance= 7.609 5. Productivity= 7.365 6. Planning Efficiency= 7.317 7. Functionality= 7.048
29	1. less waste= 83.87% 2. Improved productivity=74.19% 3. Reduced cost= 74.19% 4. fewer defects and improved quality= 64.52% 5. increased profit/turnover AND more client satisfaction 51.61%	1. Less waste= 74.19% 2. Improved productivity= 64.52% 3. Fewer defects and improved quality= 64.52% 4. More client satisfaction= 54.84% 5. improved safety and health conditions= 51.61%	1. Improved productivity= 71.43% 2. Fewer defects and improved quality= 71.43% 3. Less waste= 69.05% 4. Reduced cost= 64.29% 5. More client satisfaction= 59.52%
30	1. Cost and Value Management= 66.67% 2. Risk Management= 54.55% 3. LC= 21.21% 4. All= 18.18% 5. SC assistance= 15.15% 6. Other= 9%	1. Cost and Value Management= 48.39% 2. Risk Management= 45.16% 3. All= 32.26% 4. SC assistance= 32.26% 5. LC= 12.9% 6. Other= 6%	1. Risk Management= 60% 2. Cost and Value Management= 52.5% 3. All= 27.5% 4. SC assistance= 25% 5. LC= 17.5% 6. Other= 5%
31	1. International standards= 45.16% 2. BREEAM= 35.48% 3. All= 12.9% 4. N/A= 12.9%	1. International standards= 61.29% 2. BREEAM= 48.39% 3. SC assistance= 25.81% 4. N/A= 16.13%	1. International standards= 45.24% 2. BREEAM= 35.71% 3. SC assistance= 26.19% 4. LC= 19.05%

	5. SC assistance= 9.68% 6. LC= 9.68% 7. Other= 6%	5. LC= 9.68% 6. All= 9.68% 7. Other= 3%	5. N/A= 14.29% 6. All= 9.52% 7. Other= 11%
32	1. In-house training= 51.52% 2. Job knowledge and skills scheme= 39.39% 3. Community engagement= 33.33% 4. Team development= 24.24% 5. Safety programmes= 24.24% 6. Creating a Lean culture= 18.18% 7. All=12.12% 8. Other= 6%	1. In-house training= 51.61% 2. Community engagement= 48.39% 3. Safety programmes= 35.48% 4. Team development= 29.03% 5. Job knowledge and Skills scheme= 29.03% 6. All= 12.9% 7. Creating a Lean culture= 9.68% 8. Other= 6%	1. In-house training= 45.24% 2. Community engagement= 40.48% 3. Safety programmes= 33.33% 4. Job knowledge and Skills scheme= 33.33% 5. Team development= 28.57% 6. Lean culture= 21.43% 7. Other=16% 8. All= 11.9%
33	1. To increase our profit and /or turnover= 56.25% 2. To improve the quality of our outputs= 52.12% 3. To improve our rate of client satisfaction= 53.12% 4. To keep up-to-date = 37.5% 5. Other= 18% 6. When a major problem occurs= 15.62% 7. We are satisfied, no need to change= 5.38% 8. As a respond to the Egan's report= 5.38%	1. To improve our rate of client satisfaction= 58.06% 2. To increase our profit and /or turnover= 45.16% 3. To improve the quality of our outputs= 38.71% 4. To keep up to date= 29.03% 5. As a respond to Egan's report= 16.13% 6. Other= 16.13% 7. We are satisfied= 9.68% 8. When a major problem occurs= 3.23%	1. To improve the quality of our Outputs= 53.86% 2. To increase our profit and /or turnover= 53.86% 3. To improve our rate of client satisfaction= 51.28% 4. To keep up-to-date= 38.46% 5. As a respond to Egan's report= 20.51% 6. When a major problem occurs= 10.26% 7. Other= 10% 8. We are satisfied, No need to change= 7.69%
34	*Only barriers with a mean score of 4.0 and above will be classified as significant barriers*: Fragmentation & subcontracting= 3.829 Procurement & contracts= 3.543 Lack of adequate Lean awareness = 4.229 Cultural issues= 3.943 Time & commercial pressure= 4.0 Financial issues=3.743 Lack of top management	*Only barriers with a mean score of 4.0 and above will be classified as significant barriers*: Fragmentation & subcontracting= 3.806 Procurement & contracts= 3.774 Lack of adequate Lean awareness = 4.469 Cultural issues= 4.188 Time & commercial pressure= 3.969 Financial issues= 3.625 Lack of top management	*Only barriers with a mean score of 4.0 and above will be classified as significant barriers*: Fragmentation & subcontracting= 3.833 Procurement & contracts= 3.857 Lack of adequate Lean awareness = 4.256 Cultural issues= 4.023 Time & commercial pressure= 3.667 Financial issues= 3.326 Lack of top management

	commitment= 3.743 Design/Construction Dichotomy= 3.429 Educational issues= 3.457 Lack of process based PMS= 3.686	commitment= 4.281 Design/Construction Dichotomy= 3.645 Educational issues= 4.065 Lack of process based PMS= 3.719	commitment= 4.14 Design/Construction Dichotomy= 3.30 Educational issues= 3.429 Lack of process based PMS= 3.333
35	• Yes= 13.89%	• Yes= 19.35%	• Yes= 28.57%
36	• Yes= 29.41%	• Yes= 53.12%	• Yes= 48.54%

II. Years of Experience Sub-Classification In-depth Analysis

Q10- it appears that 72.73% of the participants with more than 20 years of experience were aware of the LCI-UK, while 75.76% of the participants with 10-20 years of experience were aware, while only 47.22% of the participants with less than 10 years of experience were aware of the LCI-UK. See Figure A9.1

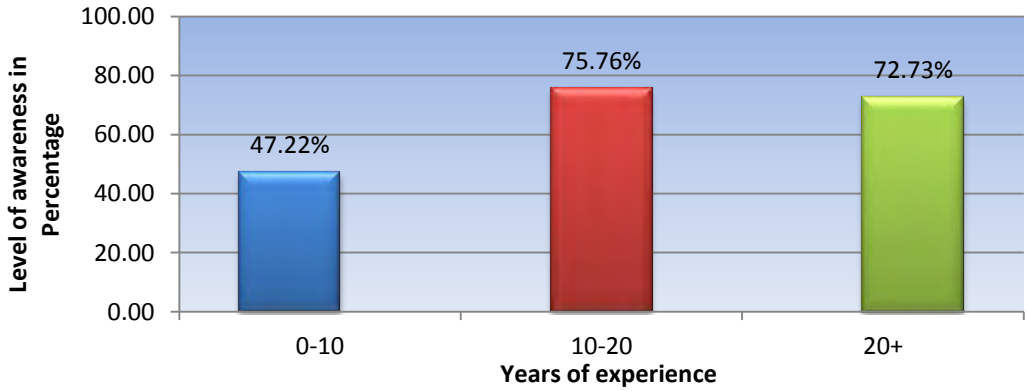


Figure A9.1: Level of awareness of the LCI-UK based on the years of experience sub-classification analysis (Author)

Q11- it is very obvious that there is strong consistency in both mode and median values (all agree on Traditional).

Q12- there seems to be strong consistency in both of the modal and median responses, but a very little difference in the mean values as respondents with more than 20+ years of experience obtained a value which is slightly higher than the others.

Q13- there seems to be no variation in the median and modal values, but a little difference in the mean values as those with 20+ years of experience obtained a slightly higher score (range 2.35 – 2.64). These results suggest that experience makes a very little difference to the level of lean commitment.

Q14- there is consistency in the modal responses, but median responses show noticeable variation, as respondents with the smallest amount of experience (1-10) years of experience provided the least optimistic responses suggesting no training, increasing slightly as experience increases.

Q15- it is clear that all agree on top two: long term contractual agreements and document management systems; and also agree on bottom three: LPDS, All, and Other. However, the 'All' option was selected by 21.43% of the respondents with 20+ years of experience decreasing steadily as experience decreases. It is also obvious that those with 10-20 years of experience ranked project information systems as 3rd, while the others ranked it considerably lower.

Q16- it seems that experience does not make a significant difference to the level of understanding of lean concepts and practices. Both answered 8 statements correctly and the range of scores was from 59.145% for respondents with 0-10 years of experience to 63.835% for those with 10-20 years of experience.

Q17- all agree on bottom 3 – All, None and Other. No obvious consensus otherwise, as each level puts tasks in different order. For example, respondents with 0-10 years of experience put standardised work 1st declining very significantly as years of experience increases. Those with 10-20 years of experience put collaborative planning schedules 1st but others ranked it lower. Also, those with 20+ years of experience put data analysis as number one but others ranked it significantly lower.

Q18- it is noticeable that the awareness of the use of LPS increases as the years of experience increases. For those with 0-10 years of experience, LPS was selected by 8.82% of the respondents and it ranked the last in order according to their modal responses; while for those with 10-20 years of experience, it was selected by 19.35% of the respondents and ranked the 6th in order. On the other side, 28.57% of those with 20+ years of experience selected LPS and it ranked the 5th in order according to their modal response.

Q19- it s noticeable that respondents with 20+ years of experience are the most aware of the techniques used for minimising uncertainty in production processes, as they put PDCA as number 1 according to their modal responses. For all other sub-classifications, PDCA came second after 'None'.

Q20- all agree on top two (not applicable and visual management). Alternatively, it seems that experience makes a noticeable difference to the level of awareness of using of LPS for organising the movement of materials, crews and production processes; as it was selected by 24.39% of the respondents with 20+ years of experience, declining significantly as experience decreases (range 11.56% - 24.39%).

Q21- it appears that those in the middle (10-20 years of experience) are the most aware of the management concepts (TQM, SCM, CE) as they achieved a score of 61.29%, while the other two groups (0-10 and 20+) achieved scores of about 39% and 41% respectively.

Q22- it can be seen that respondents with more than 20 years of experience are the most aware to supply techniques than the others.

Q23- By referring to the years of experience and managerial position sub-classifications, all except graduates agree that BIM should come 1st. However, it seems that respondents with 10-20 years of experience and holding medium managerial positions tend to have a slightly higher level of awareness to BIM than others.

Q24- it seems that those with less than 10 years of experience are slightly more aware of design concurrent and/or set-based design strategies than the others.

Q25- All agree on top two (N/A & planning as an activity schedule) and all put 'Other' at bottom. No other consensus otherwise.

Q26- there seems to be significant variations. Respondents with 10-20 years of experience are the least aware (only 3.33% provided a correct answer), respondents with 0-10 years of experience are more aware than those with 10-20 years of experience (15.15%), while respondents with 20+ years of experience are the most aware (25%). Again, as the PPC value is used as a metric for commitment reliability there tends to be a direct relation between the frequency of using LPS for performance measurement and understanding the function of the PPC value in LPS (Figure A9.2 below).

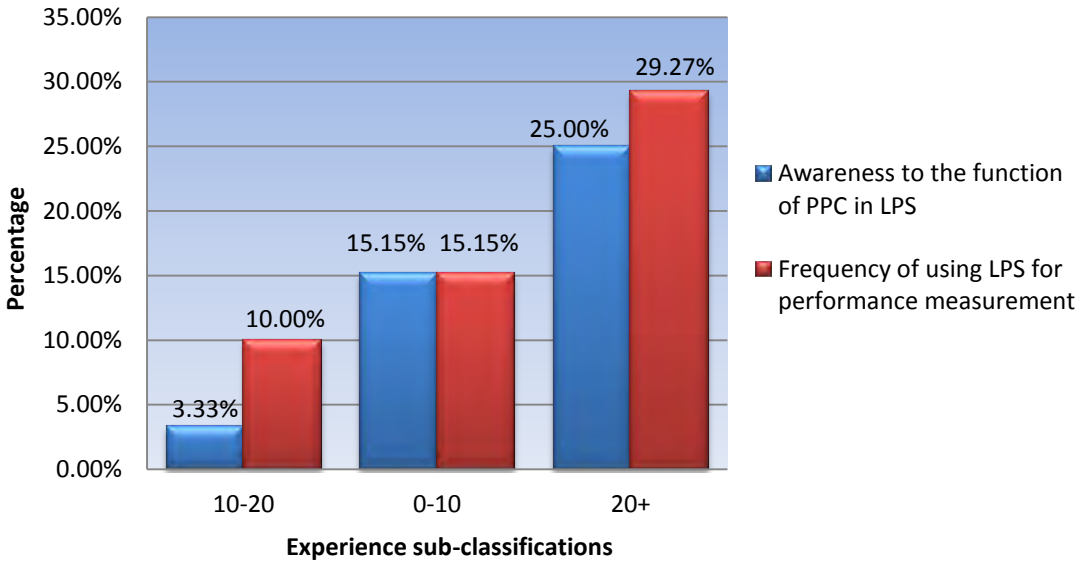


Figure A9.2: The relation between the awareness of practitioners to the function of the PPC value and the frequency of using LPS for performance measurement, based on the experience sub-classification analysis (Author)

Q27- all agree on top two (KPI and experience of managers). However, it seems that those with 20+ years of experience are more aware of the importance of establishing leading indicators and linking it to the business strategy than the others.

Q28- all sub-classifications agree on top 3 (safety, client/customer satisfaction, and then quality). There is no obvious consensus otherwise, as each group ranks the other performance measures in different order.

Q29- there seems to be a change in the modal responses. Respondents from 0-10 and 10-20 years of experience agree that the top benefit from applying lean to construction is 'less waste', but those with 20+ years of experience have a different opinion and prioritised the 'improved productivity' and 'fewer defects & improved quality' benefits to the less waste benefit. It also clear that only those from 1-10 years of experience ranked 'increased profit' as one of their top 5 expected benefits. Similarly, only those with 10-20 years of experience

included ‘improved safety and health conditions’ to their top 5 expected benefits and it replaced the ‘reduced cost’ benefit.

Q30- it appears that respondents with 0-10 years of experience are the most optimistic about the profitability of LC (21.21%, 3rd rank), then comes those with 20+ years of experience (17.5%, 5th rank), and finally those with 10-20 years of experience are the least optimistic (12.9%, 5th rank). On the other hand, the latter achieved the highest scores for supply chain assistance and the ‘All’ option (approximately 32%).

Q31- it appears that all agree on the top two (international standards and BREEAM) and the bottom choice (Other). However, it is clear that the awareness of the possibility/importance of adopting LC and supply-chain assistance (as ways for achieving environmental considerations) increases as experience increases.

Q32- it appears that those with 10-20 years experience are the least aware/optimistic about the idea of creating a lean culture within their organisations, while the most experienced (20+) are the most interested. The responses in percentage were as follows: 18.18% for those with 0-10 years, 21.43% for those with 20+, but only 9.68% for those with 10-20 years of experience and it figured in a lower level (based on the modal response sequence).

Q33- it appears that all agree on top four, but with no consistency in their modal responses. Also, the results indicate that the awareness to governmental reports, such as the Egan’s report, increases as experience increases. The Egan’s report option was selected by 5.38% of the respondents with 0-10 years of experience and it ranked at the bottom of their modal responses, 16.13% of those from 10-20 and ranked 5th and, then 20.51% of those with 20+ years of experience and also ranked 5th.

Q34- all agree on 1st (B3) and 3rd (B4). No obvious consensus in modal responses otherwise. Those with 10-20 years of experience rank the time & pressure barrier (B5) as 2nd but it decreases significantly as experience increases. Similarly, those with 20+ years of experience ranked the procurement & contractual barrier (B2) as 4th but it decreases significantly as experience decreases. See Figure A9.3 below.

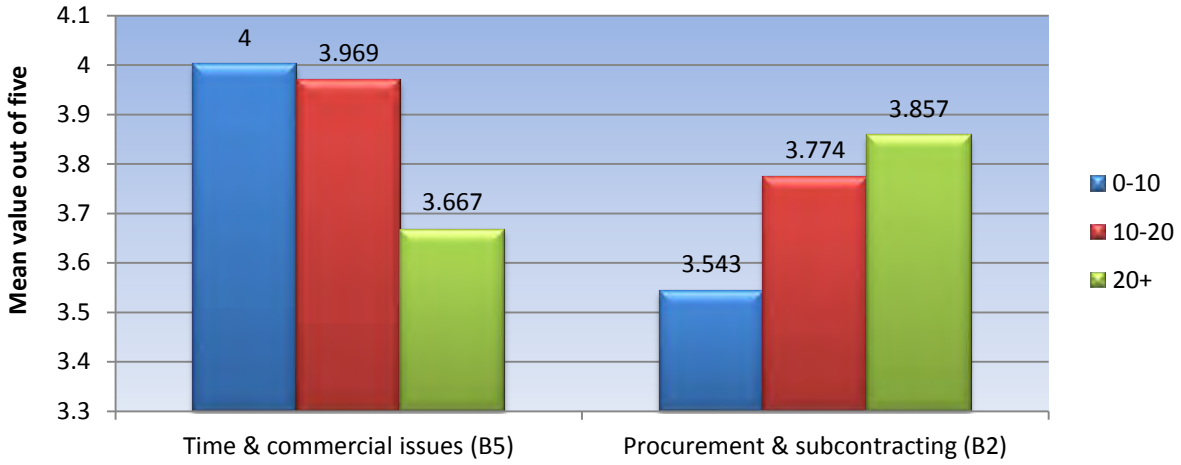


Figure A9.3: The evaluation of the effect of time & pressure and procurement & subcontracting barriers on LC, based on the years of experience sub-classification analysis (Author)

Q35- it is very obvious that respondents with more than 20+ years of experience are the most aware of the barriers to the implementation of LC (28.57%). The level of awareness then declines significantly as years of experience decreases (19.35% for those with 10-20 years of experience and then 13.89% for those with 0-10 years of experience).

Q36- it is clear that respondents who have 10-20 years of experience were the most willing (53.12%), followed by those with 20+ years of experience (48.54%), and then those with less than 10 years of experience (29.41%).

APPENDIX 10: LEVEL OF EDUCATION (QUALIFICATION) CLASSIFICATION RESULTS & ANALYSIS

I. Qualification Sub-Classification Results and Analysis

Table A10.1: Qualification Sub-Classification Results and Analysis (Author)

Q. No.	NVQ and HND/HNC	Degree	Masters
10	• 68.42% Yes	• 64.1 % Yes	• 68 % Yes
11	• Mode= 1 • Median= 3 (Leading) • Mean= 2.368	• Mode= 1 • Median= 1 (Traditional) • Mean= 2.128	• Mode= 1 • Median= 2 (Learning) • Mean= 2.04
12	• Mode= 1 • Median= 3 (Leading) • Mean= 2.368	• Mode= 3 • Median= 3 (Leading) • Mean= 2.92	• Mode= 2 • Median= 2 (Learning) • Mean= 2.58
13	• Mode= 5 • Median= 3 (Leading) • Mean= 3.167	• Mode= 2 • Median= 2 (Learning) • Mean= 2.763	• Mode= 1 • Median= 1 (Traditional) • Mean= 1.92
14	• Mode= 3 • Median= 2 (Learning) • Mean= 2.33	• Mode= 1 • Median= 2 (Learning) • Mean= 1.71	• Mode= 1 • Median= 2 (Learning) • Mean= 2.12
15	1. Collaborative Planning= 72.22% 2. Long term Contractual Arrangement= 61.11% 3. Document Management systems= 55.56% 4. Cross-Functional Teams= 50% 5. IPD= 38.89% 6. Project Information Systems= 33.33% 7. LPDS= 22.22% 8. All=16.67% 9. Other= 11%	1. Long term Contractual Arrangement= 66.67% 2. Document Management Systems= 66.67% 3. Cross-Functional Teams=48.72% 4. Project Information Systems= 41.03% 5. Collaborative Planning= 38.46% 6. IPD= 28.21% 7. LPDS= 20.51% 8. All= 20.51% 9. Other= 5%	1. Long-Term Contractual Agreements= 70% 2. Document Management Systems= 57.5% 3. Cross-Functional Teams= 40% 4. IPD= 32.5% 5. Collaborative planning= 32.5% 6. Project Information Systems= 27.5% 7. LPDS= 15% 8. All= 15% 9. Other= 7%
16	Statements they should disagree/strongly disagree with: 1) 72.22% 2) 77.78% 5) 38.89%	Statements they should disagree/strongly disagree with: 1) 64.1% 2) 82.05% 5) 30.77%	Statements they should disagree/strongly disagree with: 1) 77.5% 2) 82.5% 5) 37.5%

	Statements they should agree/strongly agree with: 3) 77.78% 4) 61.11% 6) 33.34% 7) 16.67% 8) 88.89% 9) 83.33% 10) 44.44% 11) 72.22% 7 correct out of 11 *Average score= 60.6%*	Statements they should agree/strongly agree with: 3) 64.11% 4) 61.54% 6) 23.07% 7) 43.59% 8) 92.11% 9) 57.9% 10) 56.41% 11) 84.62% *8 correct out of 11* *Average score= 60.02%*	Statements they should agree/strongly agree with: 3) 60% 4) 52.5% 6) 25% 7) 33.34% 8) 92.5% 9) 72.5% 10) 61.54% 11) 80% *8 correct out of 11* *Average score= 61.35%*
17	1. Workplace organisation= 66.67% 2. Standardised work= 66.67% 3. Problem solving= 66.67% 4. Collaborative planning= 61.11% 5. Data analysis= 61.11% 6. Visual management= 61.11% 7. Work sequence analysis= 50% 8. Process mapping= 50% 9. All= 22% 10. Other= 11% 11. None= 0%	1. Problem solving= 58.97% 2. Collaborative Planning= 56.41% 3. Data Analysis= 53.85% 4. Workplace organisation= 53.85% 5. Visual management= 51.28% 6. Standardised work= 51.28% 7. Process mapping= 48.72% 8. Work sequence analysis= 33.33% 9. All= 17.95% 10. None= 10.26% 11. Other= 7%	1. Workplace organisation= 43.59% 2. Collaborative Planning= 38.46% 3. Standardised work= 38.46% 4. Work sequence analysis= 35.9% 5. Data Analysis= 33.33% 6. Problem solving= 33.33% 7. Process mapping= 28.21% 8. Visual management= 25.64% 9. All= 17.95% 10. None= 12.82% 11. Other= 5%
18	1. CPM= 72.22% 2. Look ahead planning= 55.56% 3. PPC tools= 50% 4. Constraint analysis= 33.33% 5. Not Applicable= 22.22% 6. Workflow PM= 16.67% 7. LPS= 16.67% 8. RPS= 16.67% 9. Other= 0%	1. CPM= 60.53% 2. Look ahead planning= 44.74% 3. PCP tools= 34.21% 4. Constraint analysis= 26.32% 5. Not applicable= 18.42% 6. WF PM= 18.42% 7. Other= 18% 8. LPS= 15.79% 9. RPS= 7.89%	1. CPM= 64.1% 2. Look ahead Planning= 53.85% 3. PCP tools= 46.15% 4. Workflow PM= 30.77% 5. LPS=25.64% 6. Constraint analysis= 25.64% 7. N/A= 12.82% 8. RSPS= 10.26% 9. Other= 7%
19	1. None= 50% 2. PDCA= 33.33% 3. Prefabrication= 33.33% 4. First Run Studies= 11.11% 5. Other= 0%	1. None= 50% 2. PDCA= 38.46% 3. Prefabrication= 12.82% 4. First Run Studies= 12.82% 5. Other= 10%	1. None= 43.95% 2. PDCA= 41.03% 3. Prefabrication= 20.51% 4. FRS= 10.26% 5. Other= 10%

20	1. Not Applicable= 58.82% 2. VM= 23.33% 3. LPS= 17.65% 4. CFP=5.88% 5. Crane= 5.88% 6. Other= 5%	1. Not Applicable= 44.74% 2. VM= 34.21% 3. LPS= 13.16% 4. CFP= 10.53% 5. Crane= 10.53% 6. Other= 10%	1. N/A= 42.11% 2. VM= 34.21% 3. CFP= 26.32% 4. LPS= 23.68% 5. Other= 7% 6. Crane= 2.63%
21	• 50% Yes	• 55.26% Yes	• 52.63% Yes
22	1. JIT= 38.89% 2. Not Applicable= 33. 33% 3. Don't know= 16.67% 4. Kanban System= 11.11% 5. Value stream analysis= 5.56% 6. Other= 5%	1. Don't Know= 42.11% 2. JIT= 34.21% 3. N/A= 18.42% 4. Value stream analysis= 10.53% 5. Other= 5% 6. Kanban= 2.63%	1. Don't know= 34.21% 2. N/A= 28.95% 3. JIT= 23.68% 4. Other= 13% 5. VS analysis= 10.53% 6. Kanban= 5.26%
23	1. N/A= 47.06% 2. None= 23.53% 3. Virtual reality tools= 17.65% 4. BIM= 17.65% 5. Other= 17.65% 6. Design structure matrix= 5.88% 7. Virtual design studio= 5.88%	1. None= 34.21% 2. BIM= 26.32%% 3. N/A= 28.89% 4. Virtual reality tools= 15.79% 5. Design structure matrix= 13.16% 6. Virtual design studios= 7.89% 7. Other= 2%	1. BIM= 55.26% 2. N/A= 15.79% 3. DSM= 15.79% 4. VR tools= 15.79% 5. None= 15.79% 6. Other= 13% 7. VDS= 7.89%
24	1. N/A= 50% 2. Concurrent design= 16.67% 3. Set-based design= 16.67% 4. None= 11.11% 5. Other= 5%	1. N.A= 39.47% 2. None= 39.47% 3. Concurrent design= 13.16% 4. Set-based design= 10.53% 5. Other= 10%	1. N/A= 31.58% 2. None= 28.95% 3. Concurrent design= 26.32% 4. Set-based design= 21.05% 5. Other= 7%
25	1. N/A= 55.56% 2. Planning as an activity scheduling tool= 33.33% 3. Performance measurement= 16.67% 4. Production control= 5.56% 5. Logistics= 5.56% 6. Management control= 5.56% 7. Other= 5%	1. N/A= 67.57% 2. Planning as an activity schedule= 24.32% 3. Production control= 16.22% 4. Performance measurement= 16.22% 5. Management Control= 16.22% 6. Logistics= 10.81% 7. Other= 2%	1. N/A= 55.26% 2. Management Control= 26..32% 3. Planning= 23.68% 4. Production control= 23.68% 5. Performance measurement= 23.68% 6. Logistics= 21.05% 7. Other= 5%
26	• 5.56% (measures production planning effectiveness and workflow reliability)	• 21.62% (effectiveness& reliability)	• 16.22 % (effectiveness& reliability)
27	1. KPI= 88.24% 2. Experience of managers= 47.06%	1. KPI= 71.05% 2. Experience of managers= 71.05%	1. KPI= 71.79% 2. Experience of managers= 51.28%

	3. Own metrics= 29.41% 4. International benchmarking= 23.53% 5. Process performance measures= 23.53% 6. LPS= 11.76% 7. Balanced Score cards= 11.76% 8. DQI= 5.88% 9. QMPMS= 5.88% 10. Other= 5.88% 11. None= 0%	3. Own metrics= 50% 4. Process Performance measures= 28.95% 5. LPS= 18.42% 6. Balanced score cards= 13.16% 7. QMPMS= 10.53% 8. International benchmarking= 7.89% 9. DQI= 7.89% 10. None= 7.89% 11. Other= 2%	3. Process PM= 30.77% 4. Balanced Scorecards= 23.08% 5. Own metrics= 20.51% 6. LPS= 17.95% 7. International benchmarking= 15.38% 8. QMPMS= 10.26% 9. DQI= 5.135 10. None= 5.13% 11. Other= 2%
28	*Mean score for 'non-financial' performance indicators (Only those achieving a score of 8 and above will be considered)* 1. Safety= 9.89 2. Customer Satisfaction= 9.556 3. Quality= 9.278 4. Planning Efficiency= 8.556 5. Team performance= 8.44 6. Productivity= 8.05 7. Functionality= 7.778	*Mean score for 'non-financial' performance indicators (Only those achieving a score of 8 and above will be considered*) 1. Safety= 9.756 2. Customer Satisfaction= 9.189 3. Quality= 8.837 4. Functionality= 7.81 5. Productivity= 7.783 6. Team performance= 7.54 7. Planning Efficiency= 7.081	*Mean score for 'non-financial' performance indicators (Only those achieving a score of 8 and above will be considered)* 1. Safety= 9.589 2. Customer Satisfaction= 8.97 3. Quality= 8.717 4. Planning Efficiency= 7.897 5. Functionality= 7.842 6. Productivity= 7.794 7. Team performance= 7.717
29	1. Improved productivity=70.59% 2. fewer defects and improved quality = 70.59% 3. less waste= 64.71% 4. increased profit= 64.71% 5. improved safety and health conditions= 64.71%	1. Less waste= 73.68% 2. Improved productivity= 68.42% 3. Fewer defects and improved quality= 65.79% 4. Reduced cost= 55.26% 5. More client satisfaction= 47.37%	1. Less waste= 81.08% 2. Improved productivity= 70.27% 3. Fewer defects and improved quality= 70.27%, 4. Reduced cost= 70.27% 5. More client satisfaction= 64.86%
30	1. Risk Management= 62.5% 2. Cost and Value Management= 43.75% 3. All= 37.5% 4. SC assistance= 31.25% 5. LC= 18.75% 6. Other= 6%	1. Risk Management= 64.86%% 2. Cost and Value Management= 45.95%% 3. All= 27.03% 4. SC assistance= 27.03% 5. LC= 18.92% 6. Other= 8%	1. Cost and Value Management= 66.67% 2. Risk Management= 46.15% 3. SC assistance= 23.08% 4. All= 20.51% 5. LC= 15.38% 6. Other= 5%
31	1. International standards= 62.5% 2. SC assistance= 43.75% 3. BREEAM= 37.5% 4. LC= 18.75%	1. International standards= 47.37% 2. BREEAM= 39.47% 3. SC assistance= 23.68% 4. N/A= 13.16%	1. International standards= 46.15% 2. BREEAM= 35.9% 3. N/A= 15.38% 4. LC= 12.82%

	5. N/A= 12.5% 6. All=6.25% 7. Other= 0%	5. LC= 13.16% 6. All= 10.53% 7. Other= 7%	5. All= 10.26% 6. SC assistance= 10.26% 7. Other= 10%
32	1. In-house training= 64.71% 2. Job knowledge and skills scheme= 58.82% 3. Team development= 35.29% 4. Community engagement= 35.29% 5. Creating a Lean culture= 29.41% 6. Safety programmes= 29.41% 7. All=11.76% 8. Other= 5%	1. In-house training= 47.37% 2. Community engagement= 39.47% 3. Team development= 34. 2% 4. Job knowledge and Skills scheme= 31.58% 5. Safety programmes= 28.95% 6. Creating a Lean culture= 15.79% 7. All= 15.79% 8. Other= 15%	1. Community engagement= 48.72% 2. In-house training= 41.03% 3. Safety programmes= 33.33% 4. Job knowledge and Skills scheme= 25.64% 5. Team development= 23.08% 6. Lean culture= 12.82% 7. All= 10.26% 8. Other= 5%
33	1. To improve our rate of client satisfaction= 62.5% 2. To keep up-to-date with any new emerging management concepts= 50% 3. To increase our profit and /or turnover= 50% 4. To improve the quality of our outputs= 37.5% 5. As a respond to the Egan's report= 25% 6. When a major problem occurs/occurred=12.5% 7. Other= 12% 8. We are satisfied, no need to change= 0%	1. To improve the quality of our outputs= 55.26% 2. To improve our rate of client satisfaction= 55.26% 3. To increase our profit and /or turnover= 52.63% 4. To keep up to date= 28.95% 5. We are satisfied= 13.16% 6. Other= 13% 7. As a respond to Egan's report= 10.53% 8. When a major problem occurs= 5.26%	1. To increase our profit and /or turnover= 54.05% 2. To improve our rate of client satisfaction= 48.65% 3. To improve the quality of our outputs= 48.65% 4. To keep up-to-date= 32.43% 5. As a respond to Egan's report= 21.62% 6. Other= 13% 7. When a major problem occurs= 10.81% 8. We are satisfied, No need to change= 8.11%
34	*Only barriers with a mean score of 4.0 and above will be classified as significant barriers*: Fragmentation & subcontracting= 3.353 Procurement & contracts= 3.588 Lack of Lean awareness & understanding= 4.235 Cultural issues= 4.235 Time & commercial pressure= 3.824 Financial issues= 3.588	*Only barriers with a mean score of 4.0 and above will be classified as significant barriers*: Fragmentation & subcontracting= 3.947 Procurement & contracts= 3.684 Lack of Lean awareness = 4.231 Cultural issues= 3.846 Time & commercial pressure= 3.895 Financial issues= 3.308	*Only barriers with a mean score of 4.0 and above will be classified as significant barriers*: Fragmentation & subcontracting= 3.868 Procurement & contracts= 3.763 Lack of Lean awareness = 4.282 Cultural issues= 4.154 Time & commercial pressure= 3.846 Financial issues= 3.487

	Lack of top management commitment= 4.118 Design/Construction Dichotomy= 3.313 Educational issues= 3.412 Lack of process based PMS= 3.588	Lack of top management commitment= 3.846 Design/Construction Dichotomy= 3.324 Educational issues= 3.474 Lack of process based PMS= 3.526	Lack of top management commitment= 4.128 Design/Construction Dichotomy= 3.395 Educational issues= 3.816 Lack of process based PMS= 3.744
35	• Yes= 23.53%	• Yes= 21.62%	• Yes= 15%
36	• Yes= 35.29%	• Yes= 41.03%	• Yes= 46.15%

II. Qualification Sub-Classification In-depth Analysis

Q10- it seems that education makes very little difference to the level of awareness of the LCI-UK (range 64% - 68%).

Q11- it is obvious that there is no change in modal response, but the mean value shows marked variation as lower education obtained the highest score declining steadily as education level increases. When it comes to median responses, those holding HNC/HND provided an optimistic evaluation and obtained a median value equal to 3 (Leading), followed by those holding masters who obtained a median value equal to 2 (Learning), and then those holding a degree provided the least optimistic evaluation (Traditional).

Q12- there seems to be no consistency in the responses. Respondents holding masters obtained a median value equal to 2 (Learning) unlike the other two groups which obtained a median value equal to 3 (Leading). However, it is also obvious that respondents holding HNC/HND obtained the lowest mode and mean values, respondents holding masters came in the middle, while respondents holding a degree obtained the highest scores.

Q13- there seems to be significant variation in responses, as very optimistic responses at lower levels of education declining significantly as education level rises. See Figure A10.1.

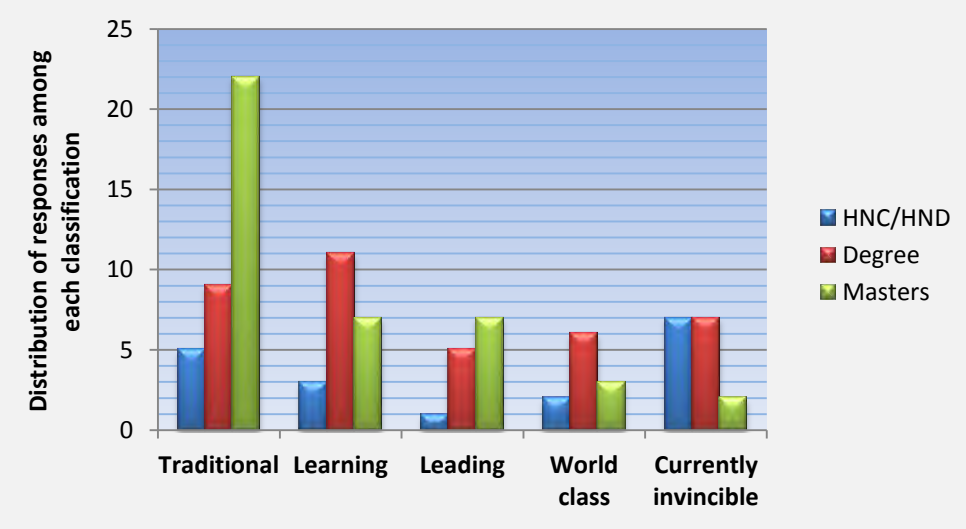


Figure A10.1: The evaluation of lean commitment within construction organisations, based on the education sub-classification analysis (Author)

Q14- there seems to be consistent median response suggesting some training, but more optimistic modal responses at lower levels of education (HNC/HND).

Q15- all agree on bottom three: LPDS, All, and Other. However, LPDS was selected by 22.22% of the respondents holding HND/HNC declining slightly as level of educations rises (range 15% - 22.22%). Also, it appears that respondents holding HNC/HND put collaborative planning as number one declining very significantly as level of education increases (range 27.27% - 72.22%).

Q16- it appears that the education does not make a difference to the level of awareness/understanding of lean concepts and practices (range 60.6% - 61.35%). However, it is important to stress that respondents holding HNC/HND were able to answer correctly 7 statements only out of 11, as opposed to the others (degree and masters) which answered 8

statements correctly. That is because respondents holding HNC/HND did not agree with S10 (they achieved a frequency score= 44.44%).

Q17- all agree on bottom 3 – All, None and Other. No obvious consensus otherwise, as each level ranks tasks in different order.

Q18- it is obvious that all agree on top three (CPM, look ahead planning, and PPC tools). Respondents holding masters ranked LPS as 5th but those holding a degree and HNC/HND put it noticeably lower.

Q19- there appears to be strong consensus in the modal responses. In all cases, None came 1st and then PDCA, Prefabrication, FRS, and other.

Q20- it comes into view that all agree on top two (not applicable and visual management). However, respondents holding masters ranked CFP as number 3, declining significantly as level of education decreases (range 5.88% - 26.32%). Also, although those holding masters ranked LPS as 4th which is one level lower than the others, they selected it more frequently than them.

Q21- it seems that education makes very little difference to the experience with the management concepts mentioned in the question (range 50% - 55%). While when referring to the managerial position sub-classification analysis, it is clear that the awareness of those management concepts (TQM, SCM, and CE) increases as the managerial position increases (range 20% - 42%) where middle management are slightly more aware than senior managers. However, when focussing on the experience sub-classification analysis, it is more obvious that those in the middle (10-20 years of experience) are the most aware as they

achieved a score of 61.29%, while the other two groups (0-10 and 20+) achieved scores of about 39% and 41% respectively.

Q22- there seems to be significant variations to the level of awareness of using JIT as a supply technique; as respondents holding HNC/HND ranked it first, declining steadily as the level of education rises (See Table A10.2).

Table A10.2: The level of awareness of JIT as a supply technique, based on the qualification sub-classification analysis (Author)

Modal Order	NVQ and HNC/HND	Bachelors degree	Masters degree
1	JIT= 38.89%	Don't Know= 42.11%	Don't know= 34.21%
2	N/A= 33.33%	JIT= 34.21%	N/A= 28.95%
3	Don't know= 16.67%	N/A= 18.42%	JIT= 23.68%

Q23- there seems to be very significant variations in the modal responses, as respondents holding masters ranked BIM as number one, declining significantly as the level of education decreases (range 17.65% - 55.26%). These considerable variations undoubtedly suggest that the level of awareness of BIM increases as the level of education increases (Table A10.3).

Table A10.3: The level of awareness of BIM, based on the education sub-classification analysis (Author)

Modal Order	NVQ and HNC/HND	Bachelors degree	Masters degree
1	N/A= 47.06%	None= 34.21%	BIM= 55.26%
2	None= 23.53%	BIM= 26.32%%	N/A= 15.79%
3	Virtual reality tools= 17.65%	N/A= 28.89%	DSM= 15.79%
4	BIM= 17.65%	Virtual reality tools= 15.79%	Virtual reality tools= 15.79%

Q24-it appears that respondents holding HNC/HND are slightly more aware to design concurrent and/or set-based design strategies than the others.

Q25- interestingly, by referring to the education and managerial position sub-classifications analysis, there seems to be an inverse relation between the level of education and the managerial position of practitioners when it comes to the application of LPS for management control. As higher education put management control 2nd but declining significantly as level of education decreases; while on contrast senior managers ranked management control as 6th but increasing significantly as managerial position decreases (Table A10.4).

Table A10.4: The relation between Level of Education / Managerial Position of the practitioner and the frequency of using LPS for Management Control (Author)

Modal Order	NVQ and HNC/HND	Bachelors Degree	Masters Degree	Graduates and Juniors	Middle-Management	Senior-Management
2	Planning= 33.33%	Planning= 24.32%	Management Control= 26.32%	Management control= 30%	Planning= 25%	Planning= 30%
3	Performance measurement = 16.67%	Production control= 16.22%	Planning= 23.68%	Planning= 20%	Management Control= 21.43%	Performance measurement = 23.33%
4	Production control= 5.56%	Performance measurement = 16.22%	Production control= 23.68%	Production control= 20%	Production control= 17.86%	Logistics= 20%
5	Logistics= 5.56%	Management Control= 16.22%	Performance measurement = 23.68%	Performance measurement = 20%	Performance measurement = 17.86%	Production control= 13.33%
6	Management control= 5.56%	Logistics= 10.81%	Logistics= 21.05%	Logistics= 10%	Logistics= 10.71%	Management Control= 13.33%

Q26- there seems to be significant variances with level of the awareness/understanding of the function of the PPC value in LPS. HNC/HND respondents were the least aware (5.5%) and those holding a degree are the most aware (21.62%). MSc came in between (16.22%).

Q27- all agree on top two (KPI and experience of managers). However, it is interesting that respondents holding HNC/HND qualification ranked international benchmarking as 4th while higher education put it significantly lower. It also, appears that those holding a degree are the most conscious about the importance of creating their own metrics. On the other hand, it is obvious that those holding a masters qualification put process performance measures and balanced scorecards as 3rd and 4th respectively, while others ranked them considerably lower.

Q28- all agree on top 3 (safety, client/customer satisfaction, and then quality). There is no obvious consensus otherwise, as each group ranks the other performance measures in different order.

Q29- it is obvious that there is consistency in the modal responses of responses holding bachelors and masters degree. Alternatively, those holding HNC/HND had a completely different view, as improved productivity figured in the top of their list; and they agreed on 'increased profit' and 'improved safety and health conditions' to be in their top 5 expected benefits instead of 'reduced cost' and 'more client satisfaction'.

Q30- the results show that lower education is more optimistic. For instance, the 'All' option was selected by 37.5% of the respondents holding HNC/HND, 27% of the respondents holding a degree, and then by only 20.5% of those holding a masters. A similar relation occurs exactly when it comes to supply-chain assistance (31.25%, 27%, and then 23%). As for LC, there does not seem to be much difference (18.75%, 18.92%, and then 15.38%).

Q31- it is very obvious that those holding HNC/HND qualifications are the most aware of the importance of LC and supply-chain assistance, as shown in Figure A10.2.

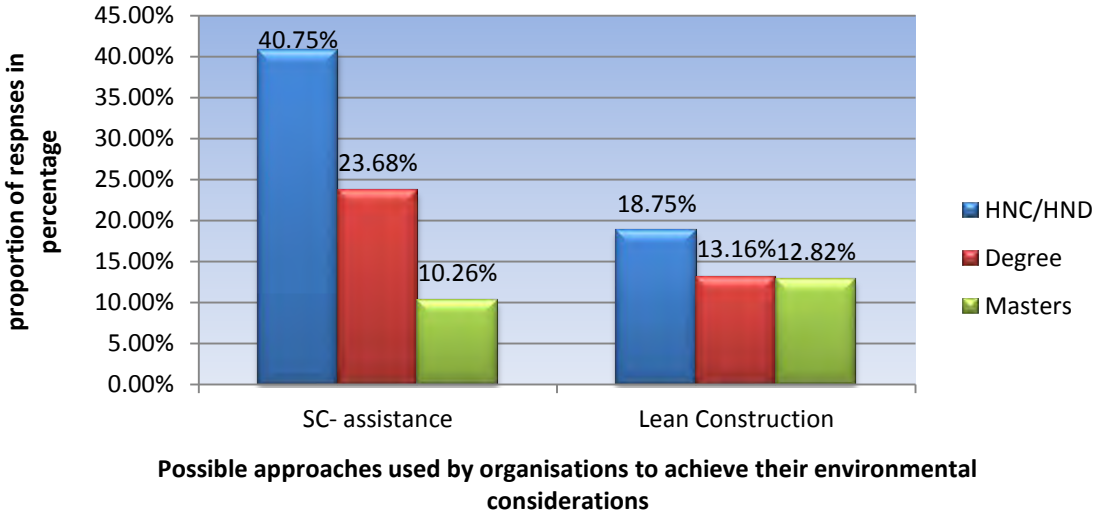


Figure A10.2: The awareness of the importance of adopting LC and supply-chain assistance to help organisations achieve their environmental considerations, based on the qualification sub-classification analysis (Author)

Q32- it is obvious that respondents holding HNC/HND and a degree are more devoted to team development than masters ones. The proportion of responses received for team development in percentage were: 35.29% for respondents holding HNC/HND, 34.2% for those holding a degree, and 23.08% for those holding a masters and it figured two levels lower than the other two based on the modal response sequence. Also, when it comes to 'Lean culture', 'Job knowledge & skills scheme' and 'in-house training', the results show optimistic responses at lower levels of education declining significantly as education level rises. On contrast, it appears that the awareness to the importance of 'community engagement' decreases as education level decreases. These relations are shown in Figure A10.3 below.

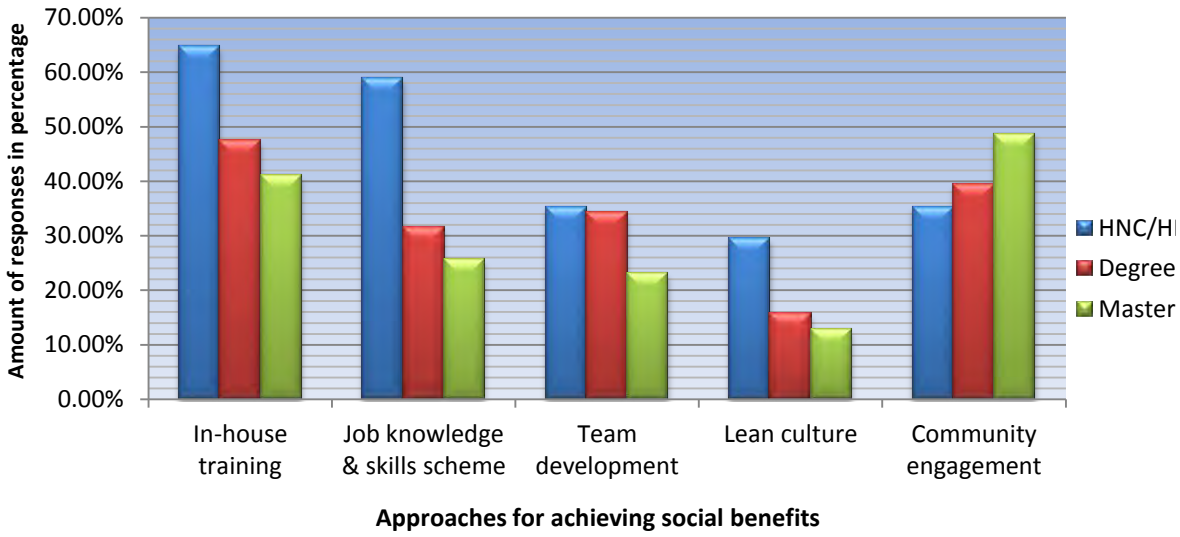


Figure A10.3: The responses to how social considerations are achieved in construction organisations, based on the education sub-classification analysis (Author)

Q33- it appears that there is no consistency amongst the three groups. At each level, the reasons are ranked differently. Also, respondents holding HNC/HND are the only group (amongst all groups in the overall secondary analysis) where the option of keeping up to date with any new emerging concepts is ranked 2nd.

Q34- all agree on 1st (B3) and 3rd (B4). No obvious consensus in modal responses otherwise. Those with 10-20 years of experience rank the time & pressure barrier (B5) as 2nd but it decreases significantly as experience increases. Similarly, those with 20+ years of experience ranked the procurement & contractual barrier (B2) as 4th but it decreases significantly as experience decreases. These relations are shown in Figure A10.4 below.

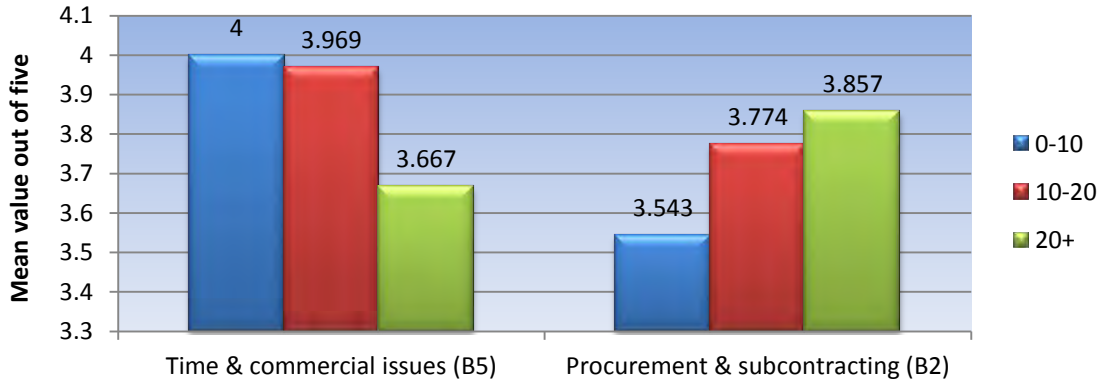


Figure A10.4: The evaluation of the effect of time & pressure and procurement & subcontracting barriers on LC, based on the years of experience sub-classification analysis (Author)

Q35- it appears that those with HND/HNC are the most aware of the barriers to the implementation of LC (23%). The level of awareness then decreases slightly as level of education rises (21.6% for those with degree and then 15% for those with masters).

Q36- it appears that those holding masters were the most willing (46.15%), followed by those holding a degree (341.03%), and then those holding HNC/HND (35.29%).

APPENDIX 11: CURRENT ROLE CLASSIFICATION RESULTS & ANALYSIS

I. Current Role (managerial level) within Organisation Sub-classification Results & Analysis

Table A11.1: Current Role within Organisation Sub-classification Results and Analysis (Author)

Q. No	Graduates and Juniors	Team leader, site manager, and project manager	Regional manager, department manager, and managerial director	Academic/Researcher
10	• 25% Yes	• 61.29 % Yes	• 76.67 % Yes	SKIP
11	• Mode= 1 • Median= 1 (Traditional) • Mean= 1.83	• Mode= 1 • Median= 1 (Traditional) • Mean= 2.06	• Mode= 1 • Median= 2 (Learning) • Mean= 2.4	
12	• Mode= 2 • Median= 2 (Learning) • Mean= 2.67	• Mode= 3 • Median= 3 (Leading) • Mean= 2.63	• Mode= 3 • Median= 3 (Leading) • Mean= 2.87	
13	• Mode= 1 • Median= 2 (Learning) • Mean= 2.4167	• Mode= 1 • Median= 2 (Learning) • Mean= 2.24	• Mode= 1 • Median= 2 and 3(Leading) • Mean= 2.77	
14	• Mode= 1 • Median= 1 (Traditional) • Mean= 1.75	• Mode= 1 • Median= 2 (Learning) • Mean= 2.275	• Mode= 1 • Median= 2 (Learning) • Mean= 2.33	
15	1. Long term Contractual Arrangement= 63.64% 2. Document Management systems= 45.45% 3. Cross-Functional Teams= 27.27% 4. Project Information Systems= 27.27% 5. Collaborative Planning= 27.27%	1. Document Management Systems= 75.86% 2. Long term Contractual Arrangement= 68.97% 3. Cross-Functional Teams= 41.38% 4. Project Information Systems= 34.48% 5. Collaborative Planning= 34.48% 6. IPD= 31.03%	1. Document Management Systems= 66.67% 2. Long-Term Contractual Agreements= 63.33% 3. Collaborative planning= 60% 4. Cross-Functional Teams= 56.67% 5. IPD= 46.67% 6. Project Information Systems= 43.33%	

	6. IPD= 18.18% 7. LPDS= 18.18% 8. All=18.18% 9. Other= 0%	7. All= 20.69% 8. LPDS= 10.34% 9. Other= 10%	7. LPDS= 30% 8. All= 10% 9. Other= 6%	
16	*Statements they should disagree/strongly disagree with:* 1) 45.45% 2) 63.63% 5) 9.09% Statements they should agree/strongly agree with: 3) 36.36% 4) 81.82% 6) 9.09% 7) 0% 8) 90.91% 9) 54.54% 10) 27.27% 11) 45.45% 4 correct out of 11 *Average score= 42.146%*	Statements they should disagree/strongly disagree with: 1) 62.07% 2) 79.31% 5) 48.28% Statements they should agree/strongly agree with: 3) 55.17% 4) 51.72% 6) 20.68% 7) 41.38% 8) 93.1% 9) 62.07% 10) 64.29% 11) 89.65% 8 correct out of 11 *Average score= 60.7%*	Statements they should disagree/strongly disagree with: 1) 76.67% 2) 83.33% 5) 36.67% Statements they should agree/strongly agree with: 3) 80% 4) 63.33% 6) 23.34% 7) 23.34% 8) 86.21% 9) 66.67% 10) 50% 11) 76.66% 8 correct out of 11 *Average score= 60.565%*	SKIP
17	1. Data analysis= 54.55% 2. Standardised work= 54.55% 3. Collaborative planning= 36.36% 4. Problem solving= 36.36% 5. Work sequence analysis= 27.2% 6. Visual management= 27.2% 7. Workplace organisation= 27.2% 8. All= 27.27% 9. Process mapping= 18.18%	1. Workplace organisation= 55.17% 2. Collaborative Planning= 44.83% 3. Visual management= 37.93% 4. Standardised work= 37.93% 5. Problem solving= 34.48% 6. Data Analysis= 31.03% 7. Process mapping= 27.59% 8. Work sequence analysis= 24.14% 9. All= 20.69% 10. None= 6.9% 11. Other= 0%	1. Collaborative Planning= 65.52% 2. Data Analysis= 62.07% 3. Workplace organisation= 62.07% 4. Standardised work= 58.62% 5. Problem solving= 58.62% 6. Work sequence analysis= 55.17% 7. Visual management= 55.17% 8. Process mapping= 48.28% 9. All= 13.79% 10. None= 6.9% 11. Other= 6%	SKIP

	10. None= 18.18% 11. Other= 0%			
18	1. CPM= 30% 2. Look ahead planning= 30% 3. PCP tools= 30% 4. N/A= 20% 5. Workflow PM= 20% 6. Constraint analysis= 20% 7. RPS= 10% 8. Other= 10% (said: Don't Know) 9. LPS= 0%	1. CPM= 75.86% 2. PCP tools= 48.28% 3. Look ahead planning= 41.38% 4. Constraint analysis= 31.03% 5. Workflow PM= 20.69% 6. LPS= 20.69% 7. Not applicable= 17.24% 8. RPS= 6.9% 9. Other= 3%	1. CPM= 63.33% 2. Look ahead Planning= 56.67% 3. PCP tools= 53.33% 4. LPS=30% 5. Constraint analysis= 23.33% 6. RSPS= 20% 7. Other= 13.33% 8. N/A= 13.33% 9. Workflow PM= 10%	SKIP
19	1. None= 50% 2. PDCA= 30% 3. Prefabrication= 20% 4. First Run Studies= 20% 5. Other= 10% (said: Don't know)	1. None= 48.28% 2. PDCA= 41.38% 3. Prefabrication= 13.79% 4. First Run Studies= 10.34% 5. Other= 3%	1. PDCA= 46.67% 2. None= 43.33% 3. Prefabrication= 30% 4. FRS= 16.67% 5. Other= 10%	
20	1. Not Applicable= 60% 2. VM= 30% 3. Crane= 20% 4. CFP=10% 5. LPS= 10% 6. Other= 0%	1. Not Applicable= 39.39% 2. VM= 43.14% 3. CFP= 21.43% 4. LPS= 14.29% 5. Crane= 3.57% 6. Other= 3.57%	1. N/A= 50% 2. VM= 30% 3. LPS= 26.67% 4. Other= 16% 5. Crane= 10% 6. CFP= 6.67%	
21	• 20% Yes (because one when asked to identify which, said: don't know. Thus excluded from those who said yes)	• 42.86% Yes	• 40% Yes	
22	1. Don't know= 40% 2. JIT= 30% 3. N/A= 20% 4. Value stream analysis= 10% 5. Other= 0% 6. Kanban System= 0%	1. Don't Know= 42.86% 2. JIT= 25% 3. N/A= 21.43% 4. Other=10% 5. Value stream analysis= 7.14% 6. Kanban= 3.57%	1. JIT= 43.33% 2. Don't know= 26.67% 3. N/A= 23.33% 4. Other= 10% 5. VS analysis= 6.67% 6. Kanban= 6.67%	

23	1. N/A= 40% 2. BIM= 30% 3. Design structure matrix= 10% 4. None= 10% 5. Other= 10% 6. Virtual reality tools= 0% 7. Virtual design studio= 0%	1. BIM= 37.93% 2. None= 27.59 3. Virtual reality tools= 24.14% 4. Design structure matrix= 17.24% 5. Virtual design studios= 10.34% 6. N/A= 10.34% 7. Other= 3%	1. BIM= 34.48% 2. None= 34.48% 3. N/A= 27.59% 4. Other= 17% 5. VR tools= 13.79% 6. DSM= 6.9% 7. VDS= 6.9%	SKIP
24	1. N/A= 60% 2. Concurrent design= 30% 3. Set-based design= 20% 4. Other= 10% (said: Don't know) 5. None= 0%	1. None= 42.86% 2. N.A= 28.57% 3. Set-based design= 21.43% 4. Concurrent design= 14.29% 5. Other= 7%	1. None= 43.33% 2. N/A= 30% 3. Concurrent design= 20%% 4. Other= 10% 5. Set-based design= 6.67%	
25	1. N/A= 50% 2. Management control= 30% 3. Planning as an activity schedule= 20% 4. Production control= 20% 5. Performance measurement= 20% 6. Logistics= 10% 7. Other= 10% (said: Don't Know)	1. N/A= 60.71% 2. Planning as an activity schedule= 25% 3. Management Control= 21.43% 4. Production control= 17.86% 5. Performance measurement= 17.86% 6. Logistics= 10.71% 7. Other= 0%	1. N/A= 60% 2. Planning= 30% 3. Performance measurement= 23.33% 4. Logistics= 20% 5. Production control= 13.33% 6. Management Control= 13.33% 7. Other= 10%	
26	• ZERO % (measures production planning effectiveness and workflow reliability)	• 22.22% (measures production planning effectiveness and workflow reliability)	• 23.33% (measures production planning effectiveness and workflow Reliability)	
27	1. Experience of managers= 70% 2. KPI= 30% 3. International benchmark= 20% 4. None= 20% 5. DQI= 10% 6. QMPMS= 10% 7. Own metrics=	1. KPI= 82.76% 2. Experience of managers= 51.61% 3. Process PM= 34.48% 4. Own metrics= 31.03% 5. Balanced score	1. KPI= 75.86% 2. Experience of managers= 68.96% 3. Own metrics= 55.17% 4. Process PM= 31.03%% 5. LPS= 24.14%	

	10% 8. Process PM= 10% 9. Other= 10% (said: Customer feedback) 10. Balanced Score cards= 0% 11. LPS= 0%	cards= 24.14% 6. LPS= 20.69% 7. International benchmarking= 10.34% 8. None= 6.9% 9. QMPMS= 6.9% 10. DQI= 0% 11. Other= 3%	6. Balanced Scorecards= 20.69% 7. International benchmarking= 13.79% 8. DQI= 10.34% 9. QMPMS= 6.9% 10. Other= 0% 11. None= 0%	
28	Mean score for 'non-financial' performance indicators (Only those achieving a score of 8 and above will be considered) 1. Safety= 9.0 2. Quality= 8.7 3. Customer Satisfaction= 8.4 4. Functionality= 7.8 5. Productivity= 7.5 6. Planning Efficiency= 7.5 7. Team performance= 7.1	Mean score for 'non-financial' performance indicators (Only those achieving a score of 8 and above will be considered) 1. Safety= 9.75 2. Customer Satisfaction= 9.142 3. Quality= 8.857 4. Functionality= 7.75 5. Team performance= 7.642 6. Productivity= 7.642 7. Planning Efficiency= 7.357	Mean score for 'non-financial' performance indicators (Only those achieving a score of 8 and above will be considered) 1. Safety= 9.8 2. Customer Satisfaction= 9.4 3. Quality= 8.67 4. Team performance= 7.7 5. Productivity= 7.6 6. Planning Efficiency= 7.43 7. Functionality= 7.413	SKIP
29	1. less waste= 88.89% 2. Improved productivity=66.67% 3. Reduced cost= 66.67% 4. fewer defects and improved quality= 55.56% 5. increased profit/turnover= 44.44%	1. Less waste= 72.41% 2. Improved productivity= 65.52% 3. Fewer defects and improved quality= 62.07% 4. Reduced cost= 55.17% 5. More client satisfaction= 51.72%	1. Fewer defects and improved quality= 82.76% 2. Improved productivity= 72.41 3. More client satisfaction= 72.41% 4. Increased Predictability= 72.41% 5. Less waste, Reduced cost, and increased profit= 65.52%	SKIP
30	1. Risk Management= 50% 2. Cost and Value	1. Cost and Value Management= 60.71% 2. Risk	1. Risk Management= 65.52% 2. Cost and Value	

	Management= 50% 3. All= 20% 4. LC= 10% 5. Other= 10% (said: Don't know) 6. SC assistance= 0%	Management= 39.29% 3. All= 28.57% 4. SC assistance= 17.86% 5. LC= 3.57% 6. Other= 0%	Management= 51.72% 3. SC assistance= 34.48% 4. All= 31.03% 5. LC= 31.03 6. Other= 5%	
31	1. BREEAM= 33.33% 2. All= 22.22% 3. N/A= 22.22% 4. SC assistance= 11.11% 5. LC= 11.11% 6. Other= 11 % (said: Don't Know) 7. International standards= 0%	1. International standards= 65.52% 2. BREEAM= 44.83% 3. SC assistance= 24.14% 4. N/A= 10.34% 5. All= 6.9% 6. LC= 3.45% 7. Other= 3%	1. International standards= 48.28% 2. BREEAM= 27.59% 3. LC= 20.69% 4. N/A= 17.24% 5. SC assistance= 17.24% 6. Other= 13% 7. All= 6.7%	SKIP
32	1. In-house training= 30% 2. N/A= 20% 3. Creating a Lean culture= 20% 4. All= 20% 5. Job knowledge and skills scheme= 10% 6. Community engagement= 10% 7. Team development= 10% 8. Safety programmes= 10% 9. Other= 10% (said: Not sure what you mean)	1. In-house training= 58.62% 2. Safety programmes= 44.83 3. Community engagement= 41.38% 4. Job knowledge and Skills scheme= 37.93% 5. Team development= 31.03% 6. All= 10.34% 7. Creating a Lean culture= 10.34% 8. Other= 0%	1. In-house training= 46.67% 2. Community engagement= 43.33% 3. Job knowledge and Skills scheme= 26.67% 4. Team development= 26.67% 5. Safety programmes= 26.67% 6. Lean culture= 20% 7. Other=13% 8. All= 10%	
33	1. To increase our profit = 55.56% 2. To improve our rate of client satisfaction= 44.44% 3. To improve the quality of our outputs= 33.33%	1. To improve the quality of our outputs= 48.28% 2. To improve our rate of client satisfaction= 48.28% 3. To increase our	1. To improve our rate of client satisfaction= 65.52% 2. To improve the quality of our Outputs= 62.07% 3. To increase our profit and /or	

	4. To keep up-to-date = 37.5% 5. When a major problem occurs= 22.22% 6. Other= 22% (they said: Don't know and N/A) 7. We are satisfied, no need to change= 11.11% 8. As a respond to Egan's report= 0%	profit and /or turnover= 48.28% 4. To keep up to date= 44.83% 5. As a respond to Egan's report= 24.14% 6. We are satisfied= 10.34% 7. When a major problem occurs= 6.9% 8. Other= 0%	turnover= 51.72% 4. To keep up-to-date= 37.93% 5. As a respond to Egan's report= 20.69% 6. Other= 10% 7. When a major problem occurs= 3.45% 8. We are satisfied, No need to change= 3.45%	
34	*Only barriers with a mean score of 4.0 and above will be classified as significant barriers*: Fragmentation & subcontracting= 3.6 Procurement & contracts= 3.4 Lack of adequate Lean awareness = 3.9 Cultural issues= 3.4 Time & commercial pressure= 3.8 Financial issues=3.4 Lack of top management commitment= 3.4 Design/Construction Dichotomy= 3.5 Educational issues= 3.7 Lack of process based PMS= 3.3	*Only barriers with a mean score of 4.0 and above will be classified as significant barriers*: Fragmentation & subcontracting= 4.03 Procurement & contracts= 3.44 Lack of adequate Lean awareness = 4.464 Cultural issues= 3.964 Time & commercial pressure= 4.07 Financial issues= 3.6 Lack of top management commitment= 4.107 Design/Construction Dichotomy= 3.23 Educational issues= 3.55 Lack of process based PMS= 3.67	*Only barriers with a mean score of 4.0 and above will be classified as significant barriers*: Fragmentation & subcontracting= 3.64 Procurement & contracts= 3.821 Lack of adequate Lean awareness = 4.25 Cultural issues= 4.035 Time & commercial pressure= 3.48 Financial issues= 3.428 Lack of top management commitment= 4.214 Design/Construction Dichotomy= 3.428 Educational issues= 3.607 Lack of process based PMS= 3.607	*Only barriers with a mean score of 4.0 and above will be classified as significant barriers*: Fragmentation & subcontracting= 4.428 Procurement & contracts= 4.28 Lack of adequate Lean awareness = 4.714 Cultural issues= 4.142 Time & pressure= 4.428 Financial issues= 4.0 Lack of top management commitment= 4.428 Design/Construction Dichotomy= 3.30 Educational issues= 4.142 Lack of process PMS= 3.857
35	• Yes= 0%	• Yes= 18.52%	• Yes= 20.69%	• Yes= 42.86%
36	• Yes= 11.11%	• Yes= 44.44%	• Yes= 44.83%	• Yes= 71.43%

- Graduates were the only category among all whose mean value for lack of adequate Lean understanding was less than 4.0 (not significant). However their mode and median scores were above 4.0.
- 50% of the graduates did not complete all questions of the survey.

II. Current Role within organisation Sub-classification In-depth Analysis

Q10- it appears very clearly that graduates/juniors are the least aware of the LCI-UK (only 25%). The level of awareness then increases very significantly as the managerial position increases, as shown in Figure A11.1.

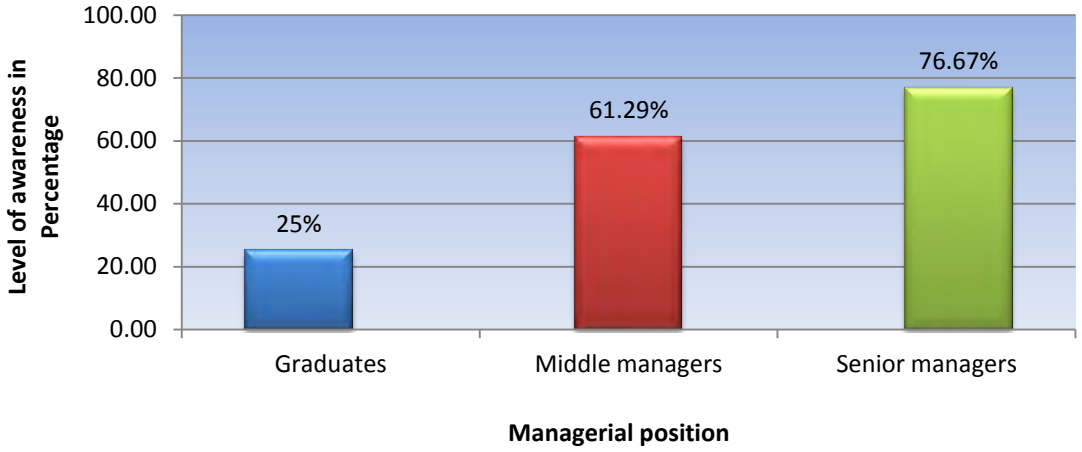


Figure A11.1: Level of awareness of the LCI-UK based on the managerial position sub-classification analysis (Author)

Q11- it appears that there is no change in modal responses and just a slight change in the median responses. However the mean values show a noticeable variation as senior managers show an optimistic evaluation declining steadily as the managerial position decreases.

Q12- there seems to be consistency in the responses of both middle and senior managers; but graduates show the least optimistic responses.

Q13- it seems that there are no variations in modal responses; but mean and median values show some variations, as graduates/juniors tend to show less optimistic responses, increasing steadily as managerial position increases.

Q14- there is no change in modal responses, but median shows obvious variations as graduates provided the least optimistic responses, increasing gradually as managerial position rises.

Q15- it appears that both middle and senior managers put document management systems 1st, but graduates/juniors ranked long term contractual agreements as 1st. Also, all agree that the 'Other' option comes at bottom. Alternatively, it is obvious that middle managers ranked LPDS slightly lower than the others. Another important observation is that senior managers ranked collaborative planning as 3rd (60%) declining noticeably as managerial position decreases (range 27.27% - 60%).

Q16- there seems to be significant variations, as graduates/juniors obtained much lower scores than middle and senior managers (range 42.146% - 60.7%). Furthermore, were able to answer only 4 statements correctly out of 11. They statements they could not answer correctly were S1, S3, S6, S7, S10 and S11. The graduates/juniors were the only group which their average level of awareness/understanding of lean concepts & practices was less than 50% (exactly 42.146%).

Q17- all agree on bottom two: None and Other. No obvious consensus otherwise. However, it seems that graduates provided more optimistic responses, as they ranked the 'All' option as 8th declining steadily as managerial position rises (range 13.79% - 27.27%).

Q18- it is very obvious that the awareness of the use of LPS increases as the managerial role increase. 'None' of the graduates/juniors within this study selected the LPS; while 20.69% of those who represent the middle management sub-classification selected LPS and it ranked

6th in order according to their modal responses. Alternatively, 30% of the senior managers selected LPS, and it came 4th in order according to their modal responses.

Q19- it appears that those with senior managerial positions are the most aware of the techniques used for minimising uncertainty in production processes, as they are the only group which put PDCA as number one.

Q20- it is obvious that graduates/juniors put crane as number 3, while middle and senior managers ranked it significantly lower. However, it appears that the managerial position makes a considerable difference to the level of awareness of using LPS for organising the movement of materials, crews and production processes; as it was selected by 10% of the graduates/juniors (ranked as 5th), increasing significantly the managerial position increases (range 10% - 26.67%), as shown in Table A11.2.

Table A11.2: The level of awareness of using LPS for organising the movement of materials, crews and production processes, based on the managerial position sub-classification analysis (Author)

Modal Order	Graduates/Juniors	Middle managers	Senior managers
3	Crane= 20%	CFP= 21.43%	LPS= 26.67%
4	CFP= 10%	LPS= 14.29%	Other= 16%
5	LPS= 10%	Crane= 3.57%	Crane= 10%

Q21- it is clear that the awareness of those management concepts (TQM, SCM, and CE) increases as the managerial position increases (range 20% - 42%) where middle management are slightly more aware than senior managers.

Q22- there seems to be noticeable variations in modal responses, as senior managers put JIT 1st while graduates and middle managers ranked it as second range (25% - 43.33%).

Q23- By referring to the years of experience and managerial position sub-classifications, all except graduates agree that BIM should come 1st. However, it seems that respondents with 10-20 years of experience and holding medium managerial positions tend to have a slightly higher level of awareness to BIM than others.

Q24- when focussing on individual sub-classifications (experience, qualification and managerial level), there seems to be a slight change in modal response. Graduates, HNC/HND qualified respondents, and those with less than 10 years of experience tend to be slightly more aware of design concurrent and/or set-based design strategies.

Q25- interestingly, by referring to the education and managerial position sub-classifications analysis, there seems to be an inverse relation between the level of education and the managerial position of practitioners when it comes to the application of LPS for management control. As higher education put management control 2nd but declining significantly as level of education decreases; while on contrast senior managers ranked management control as 6th but increasing significantly as managerial position decreases (Table A11.3).

Table A11.3: The relation between the Managerial Position / Level of Education of the practitioner and the frequency of using LPS for Management Control (Author)

Modal Order	NVQ and HNC/HND	Bachelors Degree	Masters Degree	Graduates and Juniors	Middle-Management	Senior-Management
2	Planning= 33.33%	Planning= 24.32%	Management Control= 26..32%	Management control= 30%	Planning= 25%	Planning= 30%
3	Performance measurement= 16.67%	Production control= 16.22%	Planning= 23.68%	Planning= 20%	Management Control= 21.43%	Performance measurement= 23.33%
4	Production control= 5.56%	Performance measurement= 16.22%	Production control= 23.68%	Production control= 20%	Production control= 17.86%	Logistics= 20%
5	Logistics= 5.56%	Management Control= 16.22%	Performance measurement= 23.68%	Performance measurement= 20%	Performance measurement= 17.86%	Production control= 13.33%
6	Management control= 5.56%	Logistics= 10.81%	Logistics= 21.05%	Logistics= 10%	Logistics= 10.71%	Management Control= 13.33%

Q26- none of the graduate/junior respondents were able to solve this question correctly (obtained a score equal to Zero). This is the lowest score amongst all sub-classifications of the overall secondary analysis.

Q27- it is very obvious that graduates/juniors rely very heavily on the experience of managers for performance managers. Also they are the least aware amongst all other groups within the overall secondary analysis of the importance of using process performance measures and leading indicators; as they ranked them as 7^{th} and 8^{th} but middle and senior managers put them significantly higher. Based on the graduates' modal responses, it appears that leading indicators which are linked to the business strategy, process performance measures, other, balanced scorecards, and LPS were figured in the bottom 5 respectively.

Q28- By referring to the overall secondary analysis, it appears that all sub-classifications agree on top 3 (safety, client/customer satisfaction, and then quality), except for the graduates/juniors group which ranked client satisfaction as 3rd in importance according to their viewpoint. There is no obvious consensus otherwise, as each group ranks the other performance measures in different order.

Q29- there seems to be two significant observations. First, the graduates/juniors are the only group amongst all groups in the overall secondary analysis that one of their top 5 benefits achieved a weighted score of less than 50%. Secondly, the senior managerial group is the only group amongst all groups in the overall secondary analysis that selected 'Fewer defects and improved quality' as their top expected benefit. Also, those senior managers are also the only group which added 'Increased Predictability' to their top 5 benefits list (achieving a score= 72.41%). Furthermore, 3 different benefits, namely: reduced cost,

increased profit and less waste, all weighted the same according to their views (65.52% and all three came 5th in ranking).

Q30- it is very obvious that the awareness of the importance of incorporating all these techniques/approaches increases as the managerial position increases. The same case exists with the importance of considering supply-chain assistance. Alternatively, when it comes to adopting LC, it appears that senior managers are the most optimistic, while middle managers are the least optimistic (Figure A11.2).

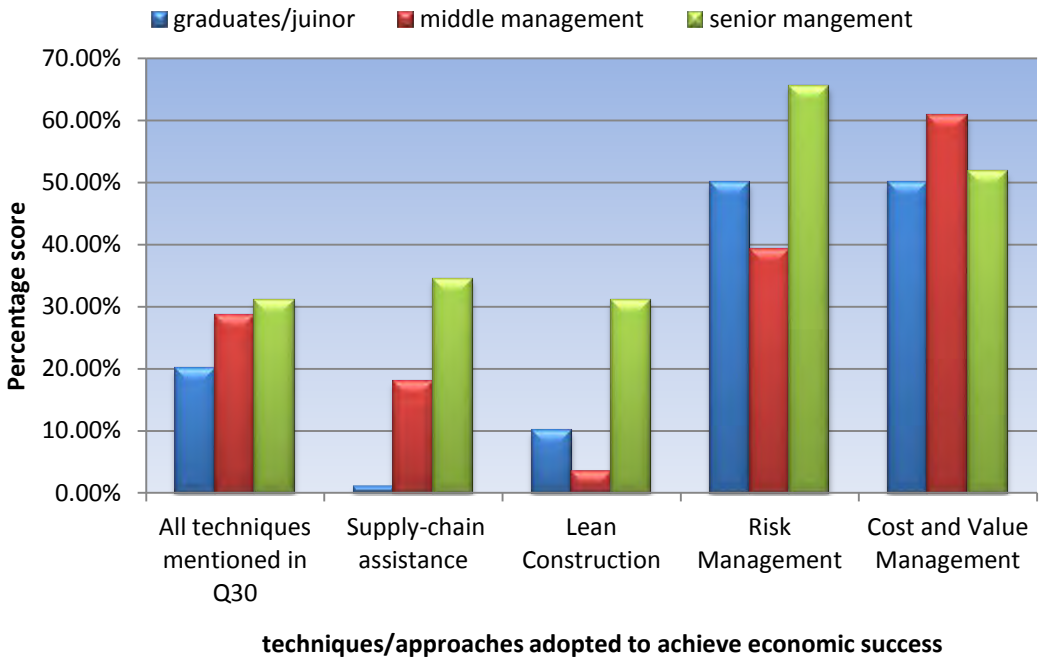


Figure A11.2: The responses to how economic success is achieved in construction organisations, based on the managerial position sub-classification analysis (Author)

Q31- there is no obvious consensus. However, it appears that graduates/juniors are not aware at all about the international standards. Although international standards always figured 1st or 2nd in the modal responses of all groups within the overall secondary analysis, it figured at the bottom list of the graduates/juniors' group and was not selected by any of

its respondents (Zero %). Also, it seems that senior managers are the most aware of the possibility of using LC as a primary tool for eliminating waste.

Q32- it is obvious that graduates/juniors are the least aware amongst all, because it is the only group which ranked 'Not applicable' as 2nd.

Q33- all agree on top three but with different priorities. The option of going on the lean journey as a respond to the Egan's report was not selected by any of the graduates/juniors.

Q34- all agree that B3 should come 1st. No other consensus in modal responses otherwise. Graduates put time & pressure (B5) 2nd while it decreases significantly as managerial position increases. On contrast, medium and senior managers ranked cultural issues (B4) as 3rd but graduates ranked it significantly lower (9th). These mean value score relations are shown in Figure A11.3 below.

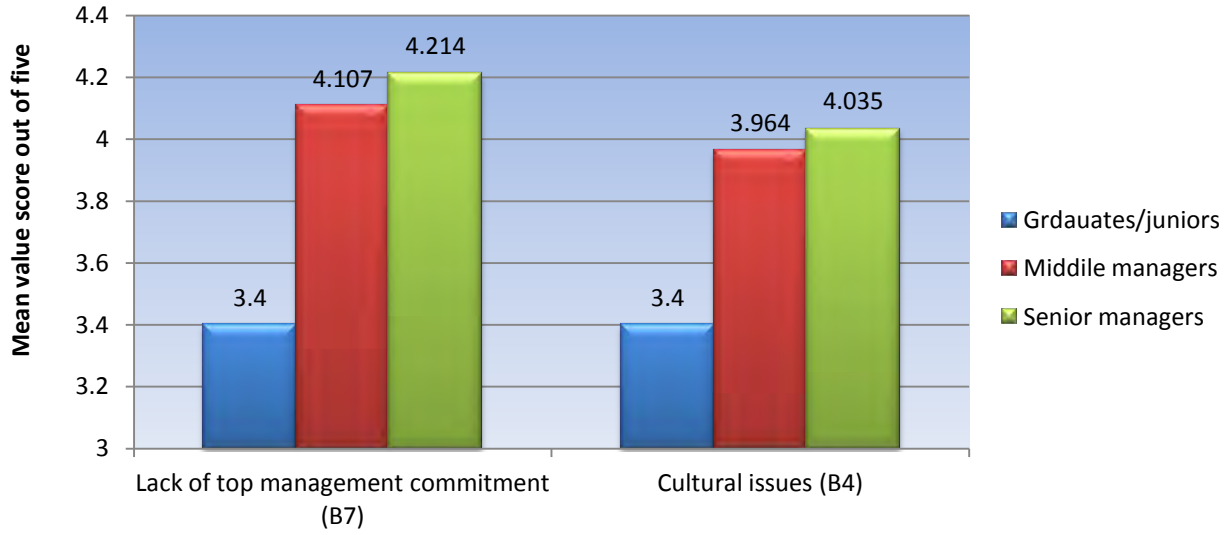


Figure A11.3: The evaluation of the effect of lack of top management commitment and cultural barriers on LC, based on the managerial position sub-classification (Author)

By referring to the academics/researchers responses to this question, it is clear that almost all of the barriers (8 out of 10) obtained a mean value score of 4.0 and above, and thus 80% of the barriers were identified as significant barriers by them. The ranking of the barriers according to their point of view is illustrated in Figure A11.4 below.

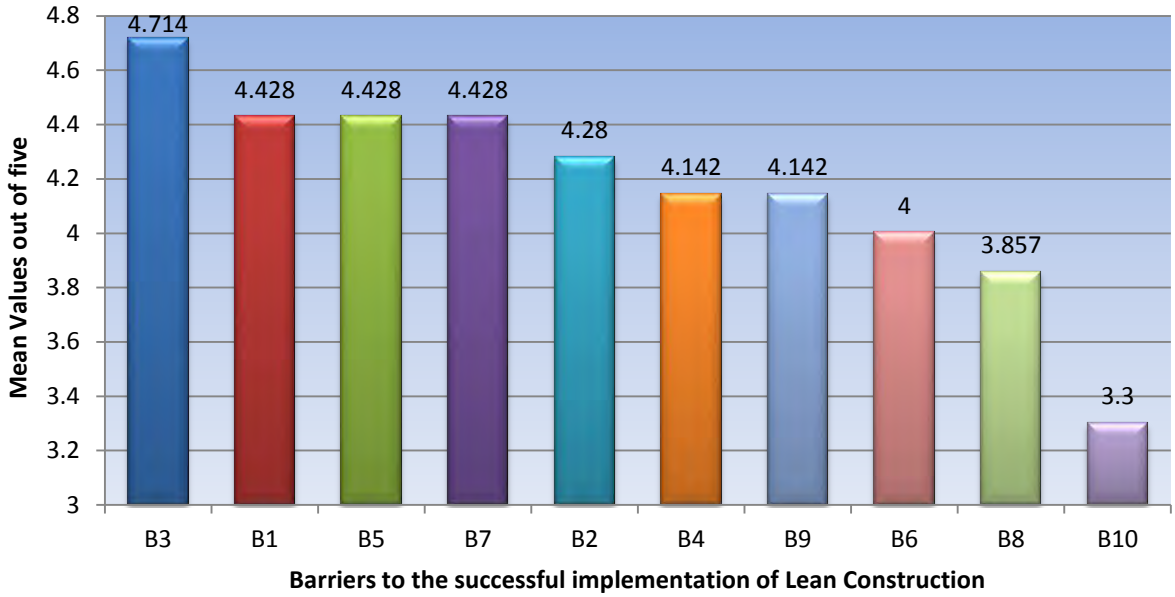


Figure A11.4: The ranking of the barriers according to their influence on the successful implementation of LC, based on the academics/researchers point of view (Author)

Q35- it is very obvious that 'None' of the graduates/juniors provided a 'Yes' answer; the rate of awareness increases significantly as the managerial position increases until almost 43% of the academics provided a 'Yes' answer (the highest frequency score amongst all groups). These results suggest that the level of awareness of the barriers to LC increases as the managerial position increases.

Q36- it clearly appears that graduates/juniors were the least willing (only 11%), while middle and senior managers were much more willing (about 44%). Furthermore, by referring to the academics/researchers responses it is clear that the most willing group amongst all to take part in interviews (71.43%).

APPENDIX 12: SURVEY REPORT

Survey Methods

Survey Software: Ask, Analyze, Improve

Survey Creation, Deployment, & Analysis Tools for Businesses

Survey: Overcoming Barriers to Lean Construction in the UK

Report: Default Report

Survey Status		Respondent Statistics		Points Summary
Status:	Live	**Total Responses:**	140	No Points Questions used in this survey.
Deploy Date:	08/01/2011	**Completes:**	112	
Closed Date:		**Partials:**	28	

Overcoming Barriers to Lean Construction in the UK

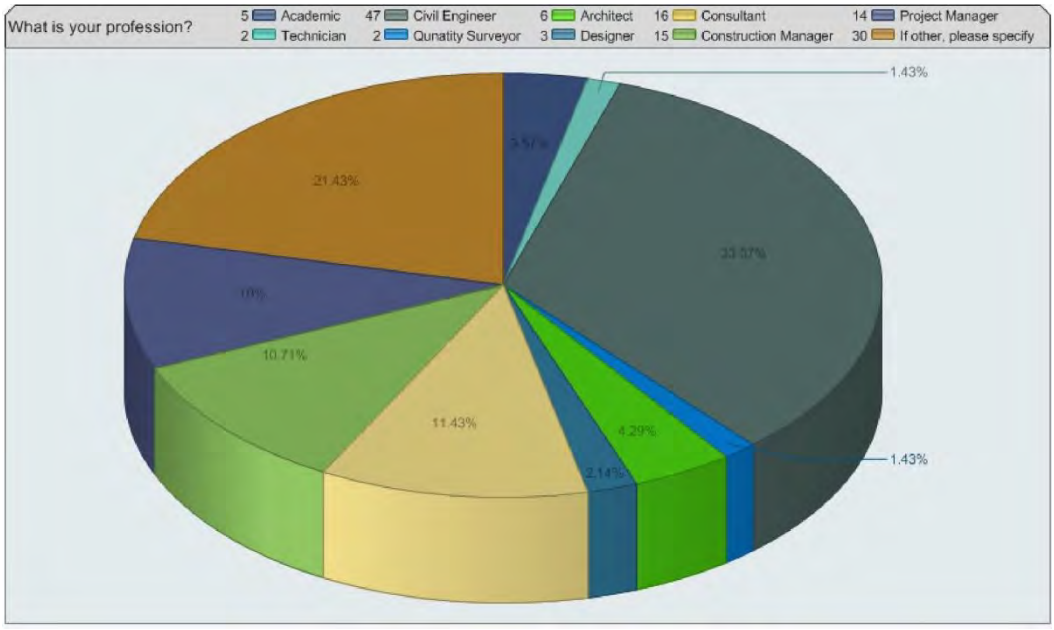
Page 2 Background Details — **Page 2 of 6**

I would like to thank you for taking the time to complete this survey.
Your participation is valuable for the success of this study.

This survey has been piloted; it takes approximately 15 - 20 minutes to complete.

1. What is your profession?

	Responses	Percent
Academic:	5	3.57%
Technician:	2	1.43%
Civil Engineer:	47	33.57%
Qunatity Surveyor:	2	1.43%
Architect:	6	4.29%
Designer:	3	2.14%
Consultant:	16	11.43%
Construction Manager:	15	10.71%
Project Manager:	14	10%
If other, please specify:	30	21.43%
Total Responded to this question:	140	100%
Total who skipped this question:	0	0%
Total:	140	100%

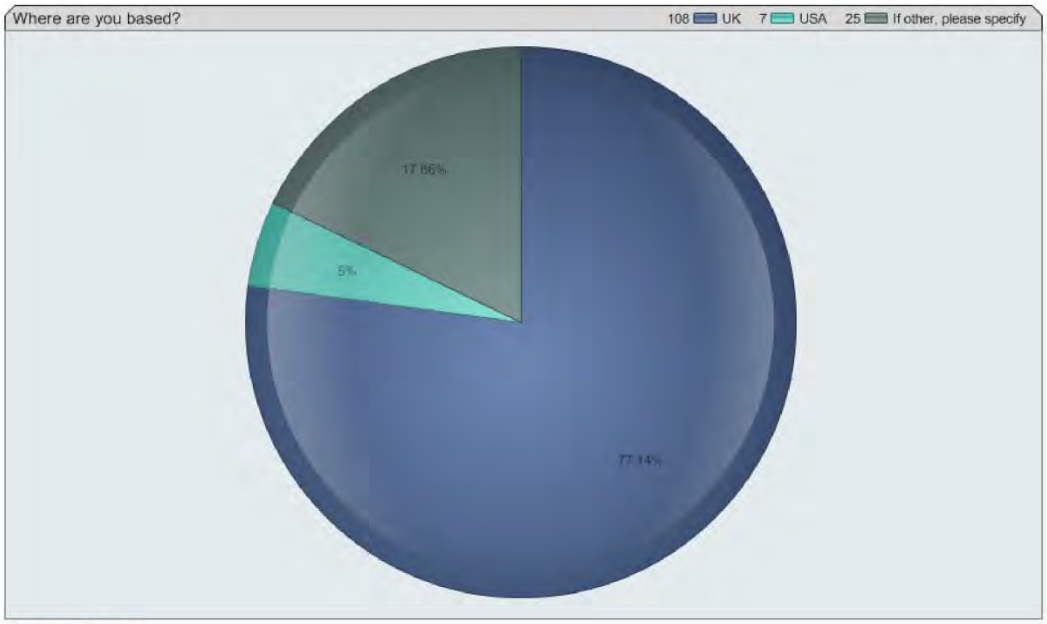


1. What is your profession?

Response	Comments
1	Postgraduate Researcher
2	Corporate Responsiblity
3	Business Improvement Manager
4	Site Engineer
5	Quality/Business Improvements Manager who also Project Manages Change
6	Now in the offshore wind business, prior to this property developer
7	Civil Engineer Professional but acting in a Business Capacity - National Manager
8	Planning Engineer
9	Operations Manager
10	Civil Engineering Recruitment Manager
11	Structural Engineer
12	Planning Claims manager
13	Director Construction company
14	Construction Director
15	Project engineer, looking after various types of construction activities in petroleum installations, not necessarily civil though I have am an MTech. in Structural Engg.
16	Pre-Construction Manager
17	Structural Engineer
18	design manager
19	Head of Procurement
20	Chartered Builder, Manager and Registered CDMC
21	water manager and geo-enginner
22	Sales
23	general manager
24	Contracts Adviser/ Legal Counsel
25	contract sales manager
26	Planning Director
27	Supplier to Construction Market
28	Senior Planning Engineer
29	speaker/author/consultant - with past experience as CE, CM & PM
30	Dimensional Control Engineer

2. Where are you based?

	Responses	Percent
UK:	108	77.14%
USA:	7	5%
If other, please specify:	25	17.86%
Total Responded to this question:	140	100%
Total who skipped this question:	0	0%
Total:	140	100%



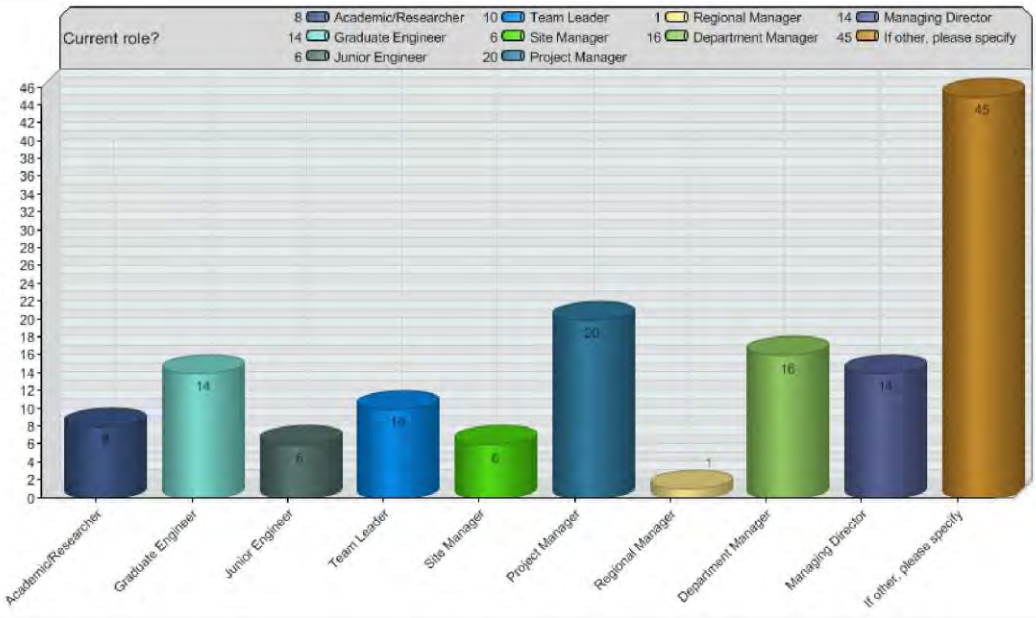
2. Where are you based?

Response	Comments
1	Ireland
2	Qatar
3	Ireland, covering the UK (and until recently, Canada)
4	singapore
5	Pakistan
6	Middle East
7	Republic of Ireland
8	Asia
9	India
10	Egypt
11	Netherlands
12	world wide , mena , africa , uk , usa asia.
13	MENA
14	Sud America (Perú)
15	Nigeria
16	Kenya
17	Sri Lanka
18	Sri Lanka
19	Ireland
20	State of Qatar
21	pakistan

22	Italy
23	china
24	Italy
25	Australia
26	Singapore

3. Current role?

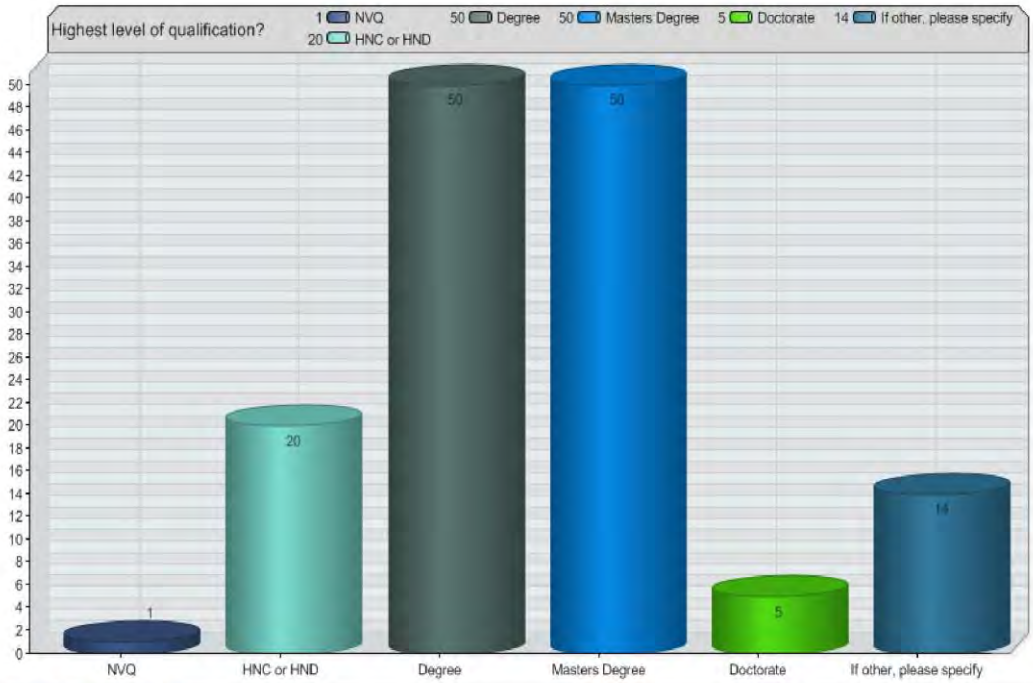
	Responses	Percent
Academic/Researcher:	8	5.71%
Graduate Engineer:	14	10%
Junior Engineer:	6	4.29%
Team Leader:	10	7.14%
Site Manager:	6	4.29%
Project Manager:	20	14.29%
Regional Manager:	1	0.71%
Department Manager:	16	11.43%
Managing Director:	14	10%
If other, please specify:	45	32.14%
Total Responded to this question:	140	100%
Total who skipped this question:	0	0%
Total:	140	100%



3. Current role?	
Response	**Comments**
1	Senior Consultant
2	Director - function lead
3	corporate responsibility
4	As in question 1
5	LEAN Project Delivery Consultant
6	Civil Engineer - Design role
7	Designer
8	Technical Director
9	Owner - Independent Consultancy
10	Contract Manager
11	Business Unit Manager
12	Architect
13	Pre Contract Manager
14	works coordination
15	Civil Engineering Recruitment Manager
16	Design Engineer
17	Productivity Manager / Lean Practitioner
18	Marine engineer
19	Chief Construction Engineer
20	Construction Planner
21	Senior Engineer
22	Development Monitor
23	freelance
24	Planning Manager
25	design manager
26	Trainer and consultant in Lean development
27	Estimator
28	Technical Product and Design Manager
29	Divisional Director
30	businbess lead and sro with p&l accountability
31	Contracts Adviser/ Legal Counsel
32	Training Engineer
33	Trade International new company
34	Consultant
35	Senior Quantity Surveyor
36	senior engineer
37	Section Engineer
38	Marketing Director
39	Director
40	Specialist blast consultant
41	assistant qs
42	Project Engineer
43	Contracts Commercial Manager
44	Professional speaker to the construction industry
45	Setting Out Engineer

4. Highest level of qualification?

	Responses	Percent
NVQ:	1	0.71%
HNC or HND:	20	14.29%
Degree:	50	35.71%
Masters Degree:	50	35.71%
Doctorate:	5	3.57%
If other, please specify:	14	10%
Total Responded to this question:	140	100%
Total who skipped this question:	0	0%
Total:	140	100%

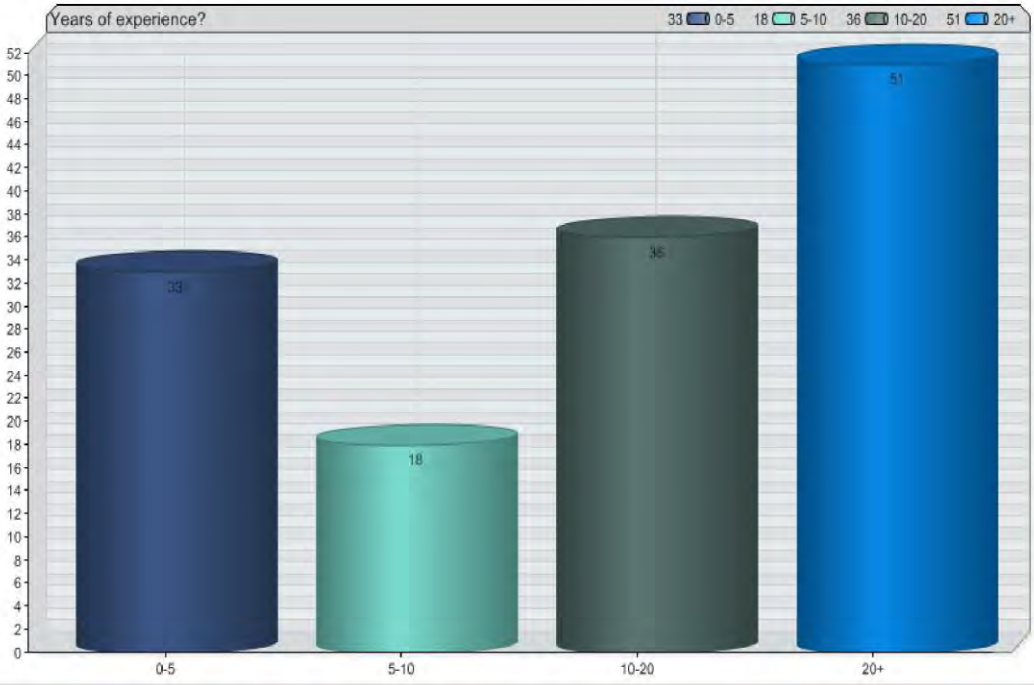


4. Highest level of qualification?

Response	Comments
1	Post graduate Diploma
2	Professional Memberships
3	Irish achieved Diploma - equivalent to B.Eng
4	IEng MICE
5	foundation degree
6	dip Arch (hons)
7	PGDip
8	Post Grad diploma in Business Management
9	CIOB Membership Examinations
10	MRICS
11	B Sc Eng (Hons) [Accredited at M Eng level by ICE (UK)]
12	Post Grad certificate
13	BS in Civil Eng, BA in general liberal arts
14	A C Inst CES

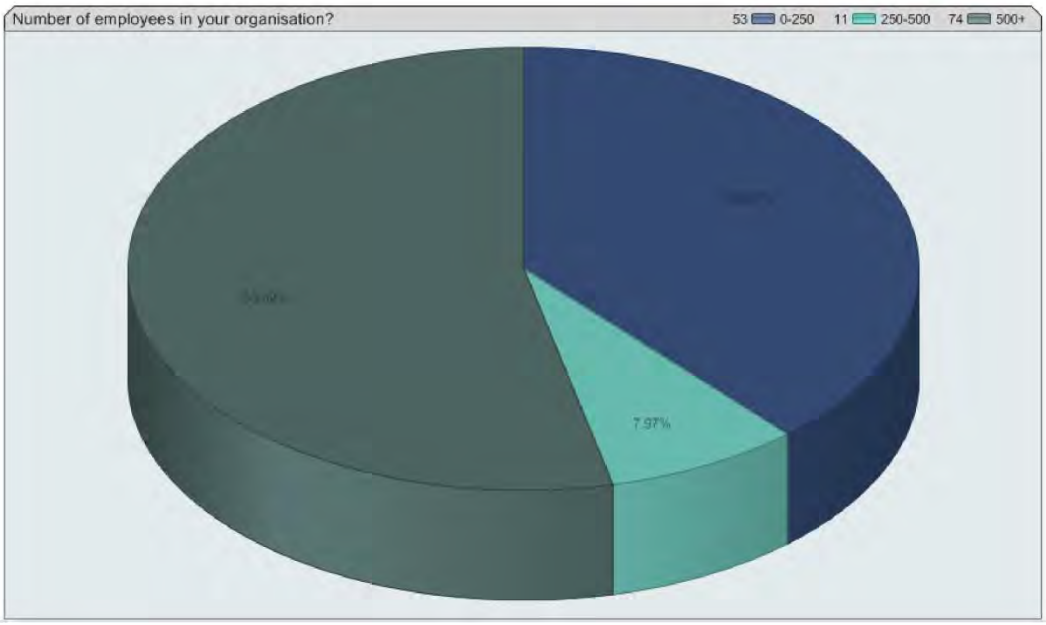
5. Years of experience?

	Responses	Percent
0-5:	33	23.91%
5-10:	18	13.04%
10-20:	36	26.09%
20+:	51	36.96%
Total Responded to this question:	138	98.57%
Total who skipped this question:	2	1.43%
Total:	140	100%



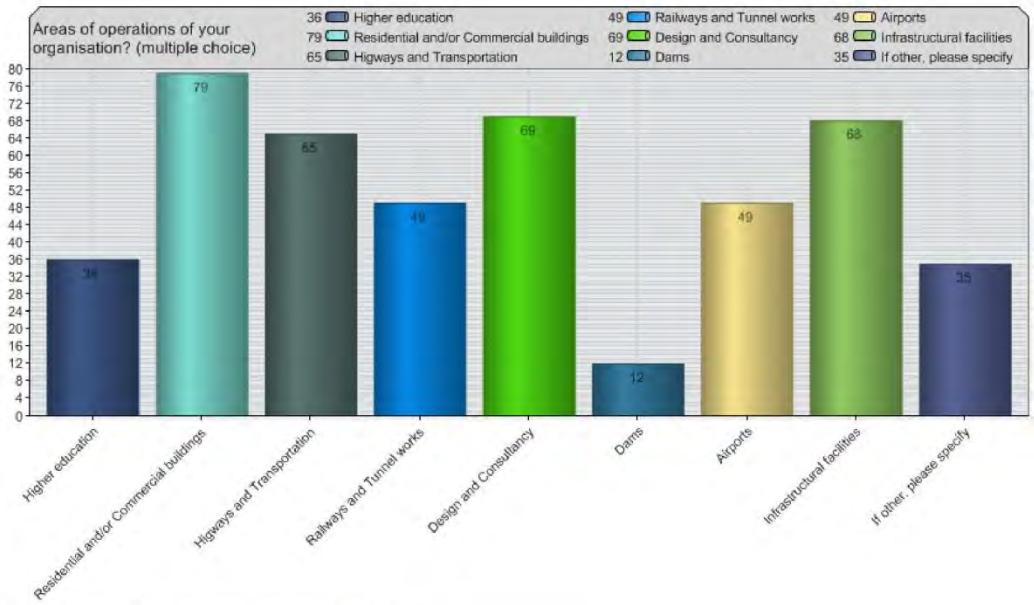
6. Number of employees in your organisation?

	Responses	Percent
0-250:	53	38.41%
250-500:	11	7.97%
500+:	74	53.62%
Total Responded to this question:	138	98.57%
Total who skipped this question:	2	1.43%
Total:	140	100%



7. Areas of operations of your organisation? (multiple choice)

	Responses	Percent
Higher education:	36	25.71%
Residential and/or Commercial buildings:	79	56.43%
Higways and Transportation:	65	46.43%
Railways and Tunnel works:	49	35%
Design and Consultancy:	69	49.29%
Dams:	12	8.57%
Airports:	49	35%
Infrastructural facilities:	68	48.57%
If other, please specify:	35	25%
Total Responded to this question:	140	100%
Total who skipped this question:	0	0%
Total:	140	100%



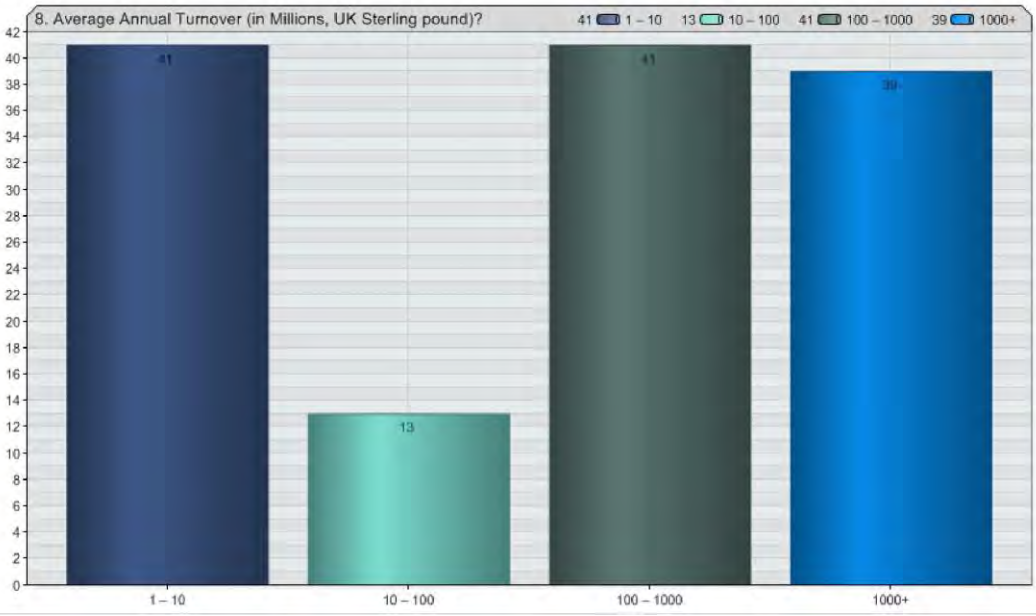
7. Areas of operations of your organisation? (multiple choice)

Response	Comments
1	housing
2	Education, Healthcare, retail, leisure, utilities, roads
3	Training, apprenticeships, industry advice etc
4	Ports and Harbours
5	Healthcare
6	Any capital project program associated with any industry, especially process and power
7	Environmental, Geotechnical
8	Manufacturing & Distribution - Engineering Products
9	Industrial
10	aerospace, defence, energy
11	Retail Interiors
12	Light Rail Infrastructure
13	Boat conctructions

14	Petroleum - refining and marketing
15	lean trainers/consultants
16	Historic Conservation
17	Oil & Gas
18	Subsea
19	Manufacturing, construction, pharma, diagnostic, textiles
20	marine and mining
21	Hotels
22	schools, hospitals, community cultural facilities
23	Rural Roads and associated structures development
24	Pharmaceutical facilities
25	Infrastructure trade
26	Harbour construction
27	Harbour construction
28	Healthcare, education
29	utilities
30	Power (Nuclear,etc.) and Telecommunication, Oil gas and chemicals, mining and metals
31	oil and gas sector
32	Professional Institute
33	General Construction
34	Health Care
35	IT Solutions

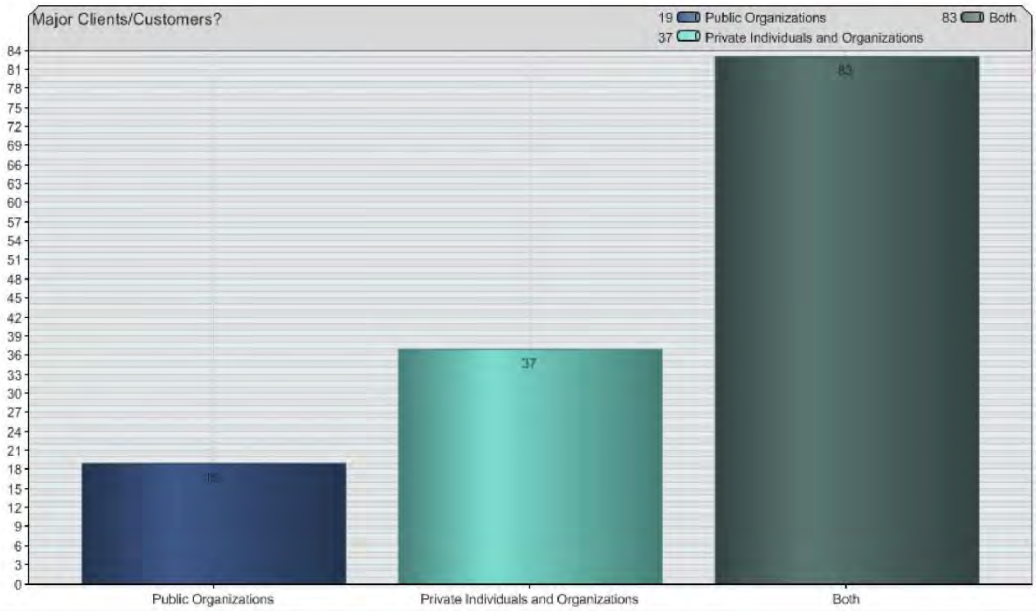
8. 8. Average Annual Turnover (in Millions, UK Sterling pound)?

	Responses	Percent
1 – 10:	41	30.6%
10 – 100:	13	9.7%
100 – 1000:	41	30.6%
1000+:	39	29.1%
Total Responded to this question:	134	95.71%
Total who skipped this question:	6	4.29%
Total:	140	100%



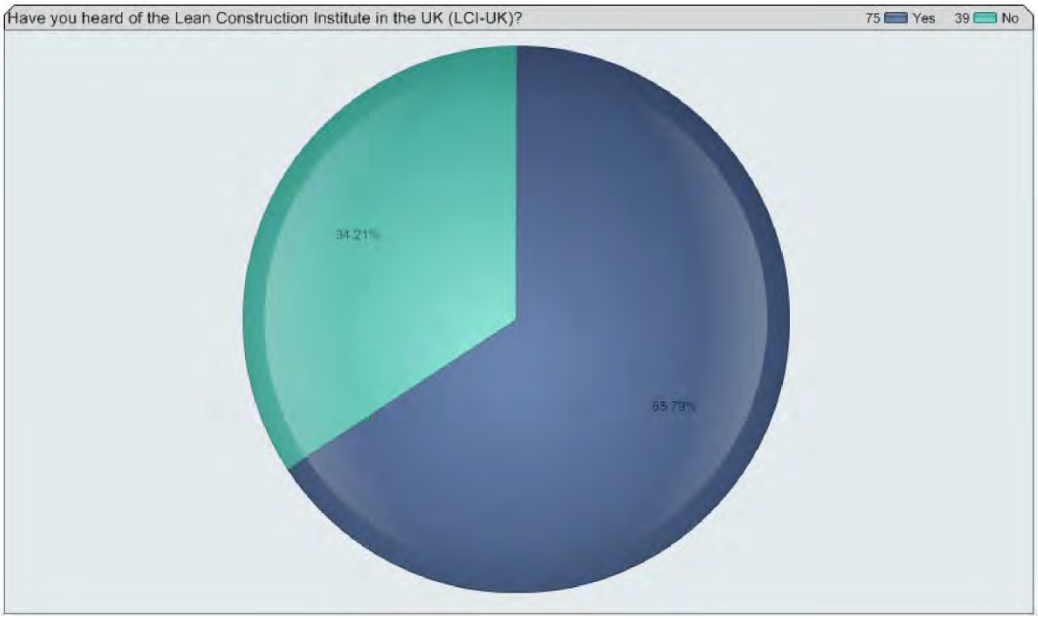
9.
Major Clients/Customers?

	Responses	Percent
Public Organizations:	19	13.67%
Private Individuals and Organizations:	37	26.62%
Both:	83	59.71%
Total Responded to this question:	139	99.29%
Total who skipped this question:	1	0.71%
Total:	140	100%



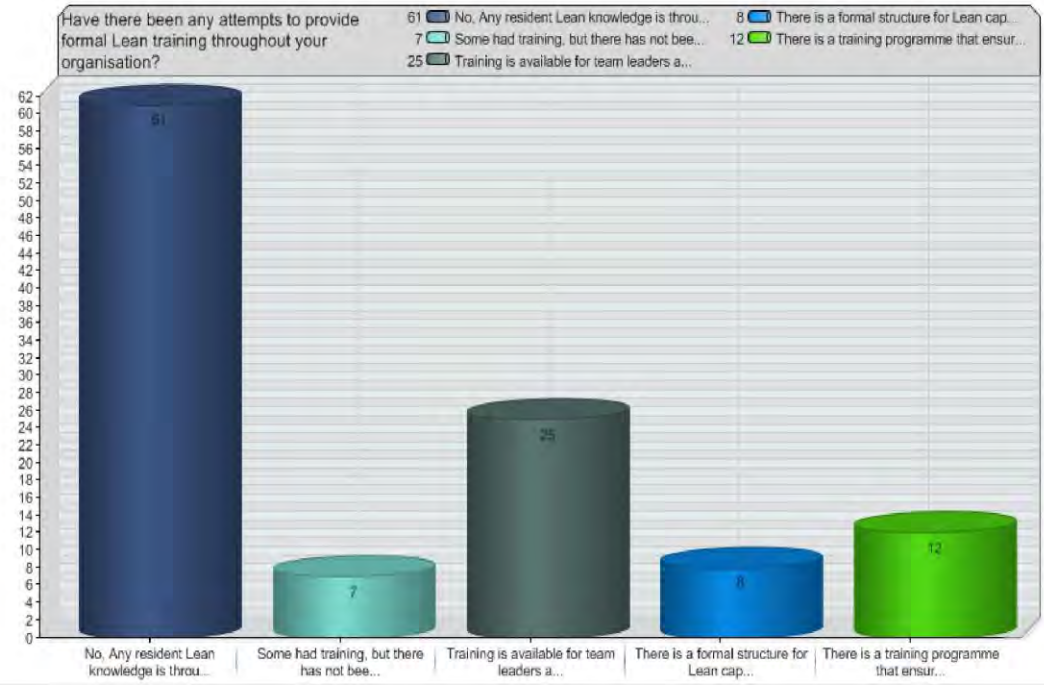
10. Have you heard of the Lean Construction Institute in the UK (LCI-UK)?

	Responses	Percent
Yes:	75	65.79%
No:	39	34.21%
Total Responded to this question:	114	81.43%
Total who skipped this question:	26	18.57%
Total:	140	100%



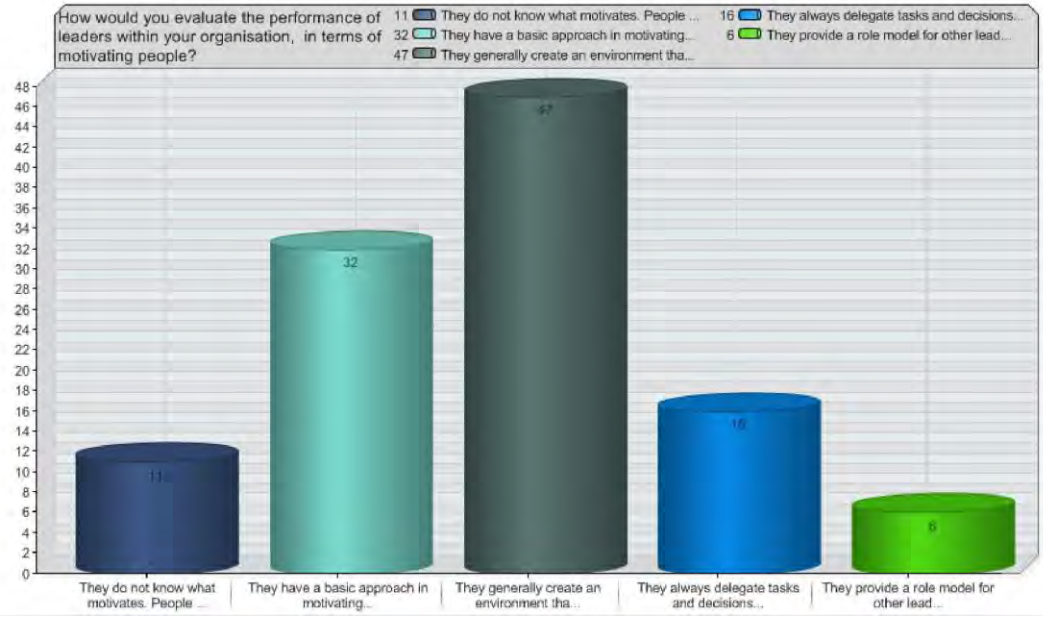
11. Have there been any attempts to provide formal Lean training throughout your organisation?

	Responses	Percent
No, Any resident Lean knowledge is through chance & personal interest:	61	53.98%
Some had training, but there has not been any chance to put the learning into practice:	7	6.19%
Training is available for team leaders and project team members, but the overall Lean capability is patchy:	25	22.12%
There is a formal structure for Lean capability building, but not everyone attends Lean awareness sessions:	8	7.08%
There is a training programme that ensures that the organisation has the optimum blend of Lean awareness:	12	10.62%
Total Responded to this question:	113	80.71%
Total who skipped this question:	27	19.29%
Total:	140	100%



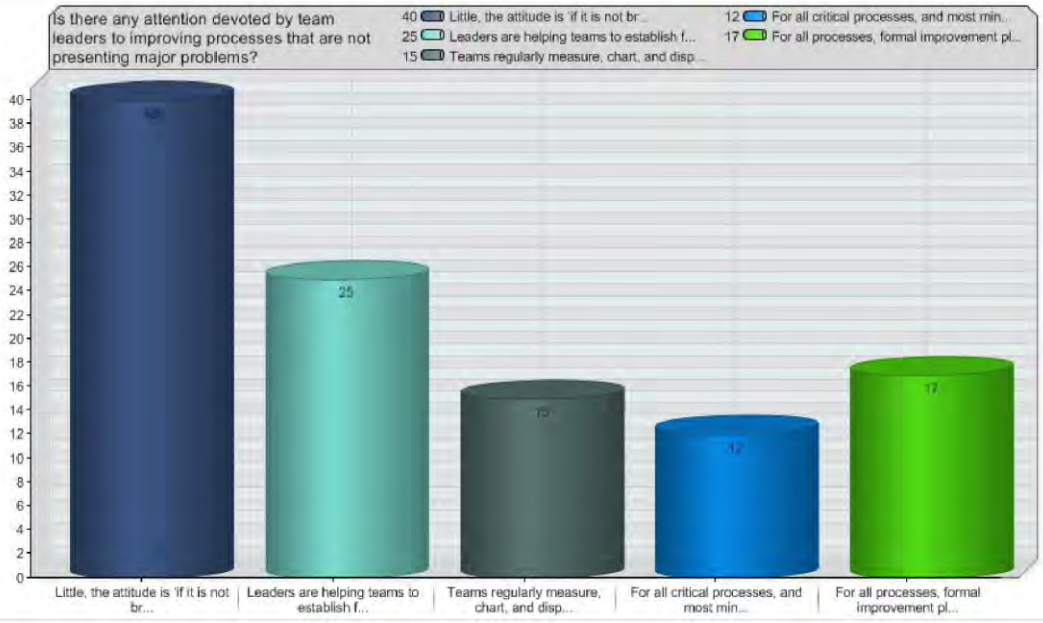
12. How would you evaluate the performance of leaders within your organisation, in terms of motivating people?

	Responses	Percent
They do not know what motivates. People under them don't do their best.:	11	9.82%
They have a basic approach in motivating people:	32	28.57%
They generally create an environment that people want to do their best in:	47	41.96%
They always delegate tasks and decisions down, and share ownership and visibility:	16	14.29%
They provide a role model for other leaders through the way they motivate people. They are currently invincible.:	6	5.36%
Total Responded to this question:	112	80%
Total who skipped this question:	28	20%
Total:	140	100%



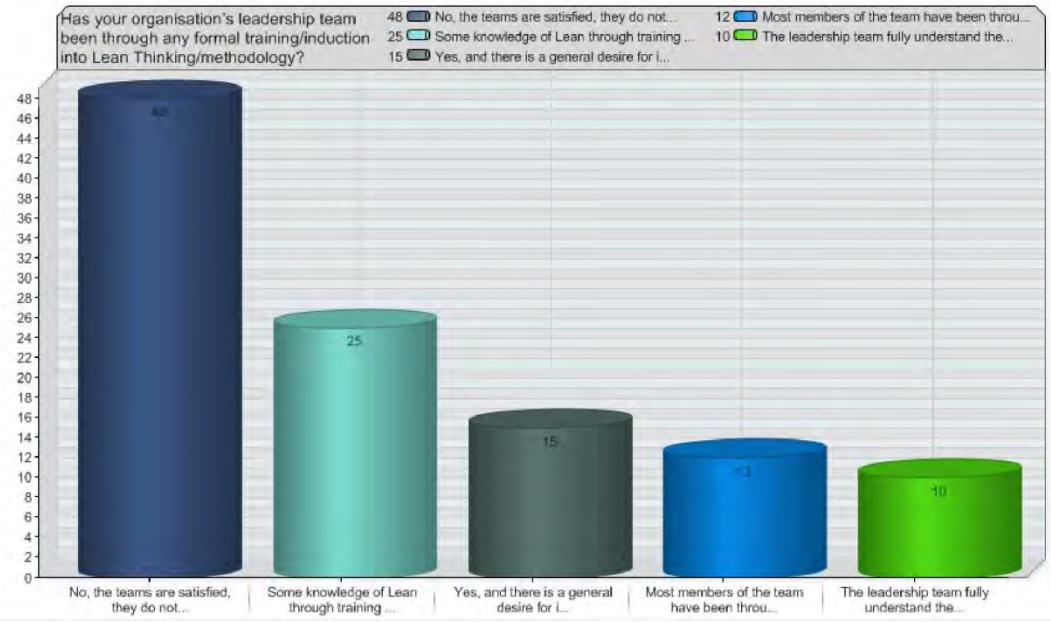
13. Is there any attention devoted by team leaders to improving processes that are not presenting major problems?

	Responses	Percent
Little, the attitude is 'if it is not broke...' Many workarounds are used to accommodate long standing process constraints:	40	36.7%
Leaders are helping teams to establish formal efforts to measure, chart, and display the performance of critical processes:	25	22.94%
Teams regularly measure, chart, and display the effectiveness of critical processes:	15	13.76%
For all critical processes, and most minor processes, effectiveness is frequently, measured, charted and displayed:	12	11.01%
For all processes, formal improvement plans are seamlessly woven into the day-to-day activities of the team:	17	15.6%
Total Responded to this question:	109	77.86%
Total who skipped this question:	31	22.14%
Total:	140	100%



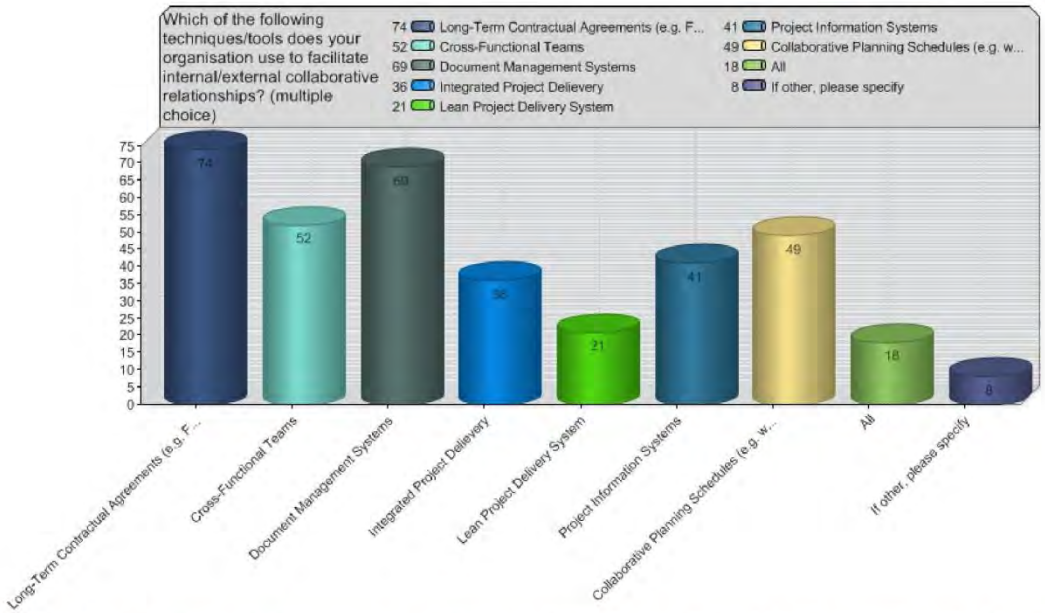
14. Has your organisation's leadership team been through any formal training/induction into Lean Thinking/methodology?

	Responses	Percent
No, the teams are satisfied, they do not need to know anything further on the subject:	48	43.64%
Some knowledge of Lean through training sessions which is adequate for involvement in Lean:	25	22.73%
Yes, and there is a general desire for increasing understanding but time pressure makes this difficult:	15	13.64%
Most members of the team have been through Lean awareness workshops:	12	10.91%
The leadership team fully understand the subject matter, and most team members have atleast a basic understanding:	10	9.09%
Total Responded to this question:	110	78.57%
Total who skipped this question:	30	21.43%
Total:	140	100%



15. Which of the following techniques/tools does your organisation use to facilitate internal/external collaborative relationships? (multiple choice)

	Responses	Percent
Long-Term Contractual Agreements (e.g. Frameworks & Partnering):	74	67.27%
Cross-Functional Teams:	52	47.27%
Document Management Systems:	69	62.73%
Integrated Project Delievery:	36	32.73%
Lean Project Delivery System:	21	19.09%
Project Information Systems:	41	37.27%
Collaborative Planning Schedules (e.g. with subcontractors or suppliers):	49	44.55%
All:	18	16.36%
If other, please specify:	8	7%
Total Responded to this question:	110	78.57%
Total who skipped this question:	30	21.43%
Total:	140	100%



15. Which of the following techniques/tools does your organisation use to facilitate internal/external collaborative relationships? (multiple choice)

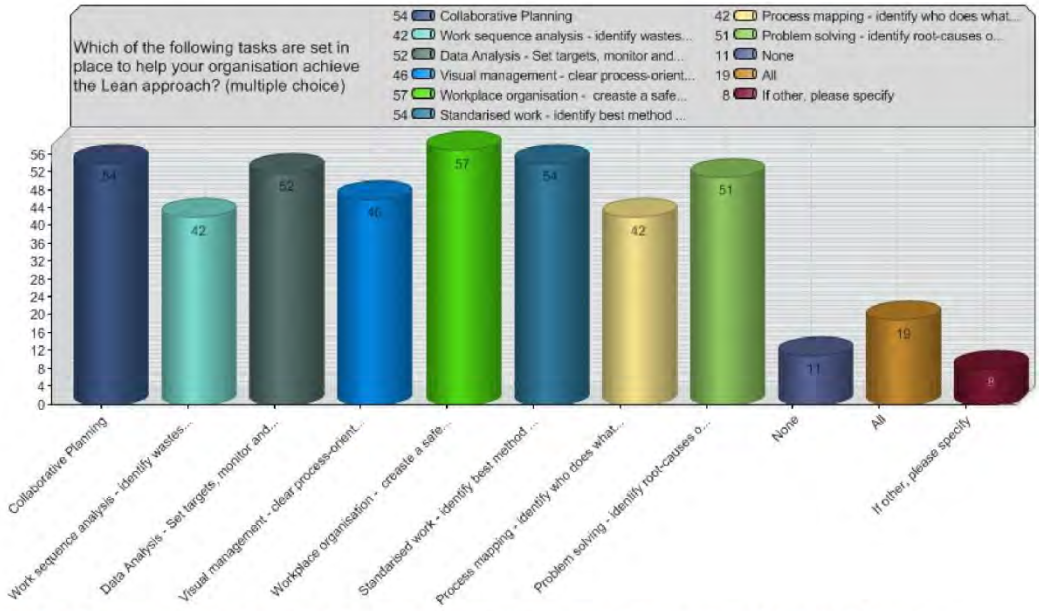
Response	Comments
1	Through ECI in areas around the business planning is strong and a right first time approach established.
2	Project Grace (Balfour Beatty Group wide) initiative covers all of the above points
3	Knowledge management/share is available to limited number of employees.
4	Joint Strategic Planning regularly designing and amending rolling 5 and 10 year plans ensuring all parties take a long term view.
5	Lean Visual Management Boards and Meetings
6	Last Planner
7	Team Building Workshops and Project Charter
8	BIM for architectural models and for cross-discipline models

16. To what extent do you agree/disagree with the following sentences?

	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree	Total
Lean concept is not suitable for the construction industry because of the demands from clients for quicker and cheaper projects:	2(1.8%)	12(10.81%)	17(15.32%)	35(31.53%)	45(40.54%)	111
There is no need to improve processes that are not presenting major problems:	3(2.7%)	6(5.41%)	11(9.91%)	61(54.95%)	30(27.03%)	111
Contract forms that allow one party to impose power over another, create adversarial relations. These adversarial relations create transaction costs, which are considered waste:	31(27.93%)	44(39.64%)	22(19.82%)	10(9.01%)	4(3.6%)	111
Lean has to be implemented across the business and value chain to deliver the promised results; any isolated efforts may even cause waste:	16(14.41%)	50(45.05%)	21(18.92%)	20(18.02%)	4(3.6%)	111
Using performance measurement for self-defence or evidence for claims and counter-claims is recommended:	6(5.41%)	33(29.73%)	35(31.53%)	28(25.23%)	9(8.11%)	111
The use of bills of quantity (BoQ) based on the Civil Engineering Standard Method of Measurement (CESMM), could lead to price variations and delivery difficulties:	8(7.21%)	23(20.72%)	45(40.54%)	33(29.73%)	2(1.8%)	111
Traditional performance preferences measured in projects, specifically costs and schedule, are not appropriate for continuous improvement:	5(4.55%)	34(30.91%)	16(14.55%)	50(45.45%)	5(4.55%)	110
All activities of the organisation/site should be continuously improved:	53(48.18%)	47(42.73%)	4(3.64%)	5(4.55%)	1(0.91%)	110
Quality should be first priority, not profit:	23(20.91%)	53(48.18%)	11(10%)	18(16.36%)	5(4.55%)	110
Any procurement form that tends to delegate design work to external designers, separates the design from the construction process; and therefore misses the lean aim of collaboration and integration:	16(14.55%)	44(40%)	28(25.45%)	17(15.45%)	5(4.55%)	110
Lean is more than tools or techniques; it requires a transformation in thinking, collaboration, flexibility, commitment, discipline, and a broad system-wide focus:	55(49.55%)	34(30.63%)	20(18.02%)	1(0.9%)	1(0.9%)	111
				Total Responded to this question:	111	79.29%
				Total who skipped this question:	29	20.71%

17. Which of the following tasks are set in place to help your organisation achieve the Lean approach? (multiple choice)

	Responses	Percent
Collaborative Planning:	54	50%
Work sequence analysis - identify wastes and risks, and consider logistics:	42	38.89%
Data Analysis - Set targets, monitor and improve:	52	48.15%
Visual management - clear process-oriented performance information - identify problems before they occur:	46	42.59%
Workplace organisation - creaste a safe and good workplace environment to complete the job:	57	52.78%
Standarised work - identify best method to achieve quality, cost and time, safely and consistenly:	54	50%
Process mapping - identify who does what, when, why and how:	42	38.89%
Problem solving - identify root-causes of problems:	51	47.22%
None:	11	10.19%
All:	19	17.59%
If other, please specify:	8	7%
Total Responded to this question:	108	77.14%
Total who skipped this question:	32	22.86%
Total:	140	100%

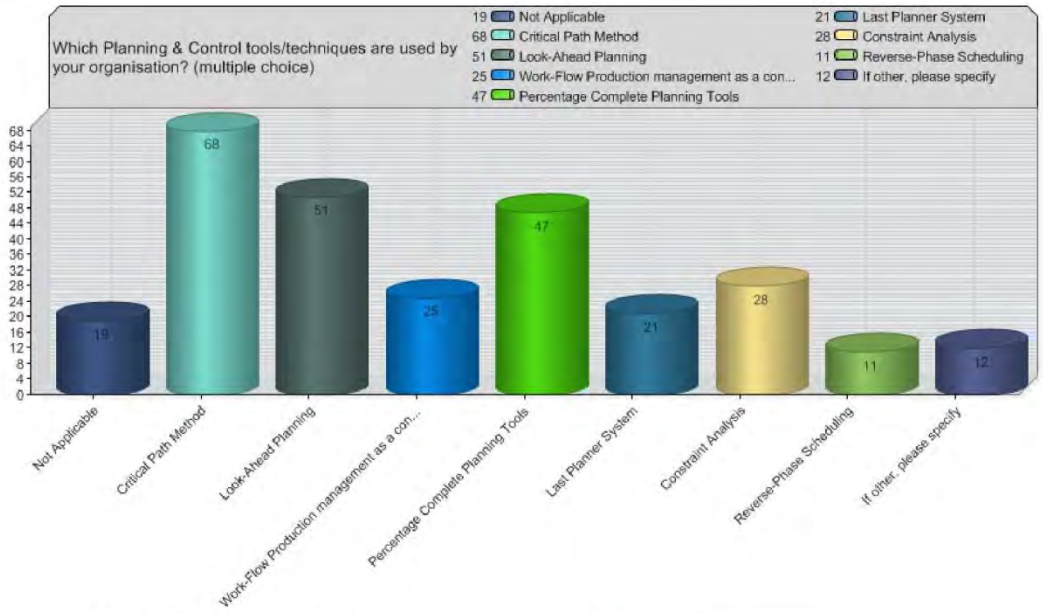


17. Which of the following tasks are set in place to help your organisation achieve the Lean approach? (multiple choice)

Response	Comments
1	Thing is with a large organisation you can never say something is or isn't in place, especially when decision making is decentralised. So Yes, and No to all of the above!!
2	This has been done on a relatively wide basis through a 5S/SMED approach in order to gain a wider understanding and buy in. Once in place the organisation has been able to easily identify further improvements and focus on them. The more complex the improvement, in general the less people involved in the analysis but again a wider involvement is needed to implement and ensure sustainability.
3	Stand Up Meetings at the workplace Knowledge Management
4	Vision Creation - helping to identify the core purpose of what we are trying to achieve in order to do the right thing - not just do things right. More waste is spent doing the wrong thing right than doing right thing wrongly.
5	The above are not implimnted in the organisation that I work for, however, they are areas that I personally am seeking to develop where and when possible.
6	I do not think achieving lean approach should be an aim (sounds a bit religious!). The aim should be to fulfill client requirements within the shortest possible timeframe and at the lowest possible cost.
7	Many other techniques tested and adapted over 25 yewars application of Lean.
8	Leader standard work

18. Which Planning & Control tools/techniques are used by your organisation? (multiple choice)

	Responses	Percent
Not Applicable:	19	17.59%
Critical Path Method:	68	62.96%
Look-Ahead Planning:	51	47.22%
Work-Flow Production management as a construction scheduling tool:	25	23.15%
Percentage Complete Planning Tools:	47	43.52%
Last Planner System:	21	19.44%
Constraint Analysis:	28	25.93%
Reverse-Phase Scheduling:	11	10.19%
If other, please specify:	12	11%
Total Responded to this question:	108	77.14%
Total who skipped this question:	32	22.86%
Total:	140	100%

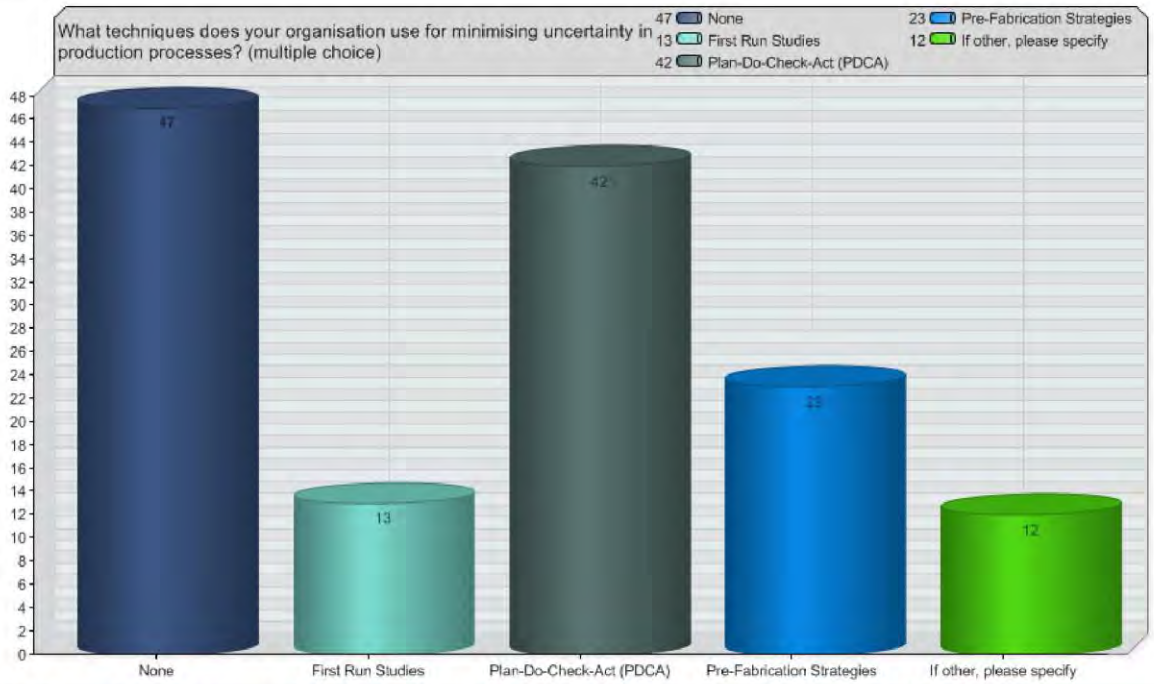


18. Which Planning & Control tools/techniques are used by your organisation? (multiple choice)

Response	Comments
1	See previous comment
2	Don't know
3	line of balance, location based planning
4	Constant Analysis of workload
5	Earned Value Analysis
6	Shouldn't Line of Balance programming also be one of the options here? LOB is one of the best Lean programming tools, as it is designed to optimise flow (unlike CPM)
7	Project, target, stage and 2 weekly programmes also used
8	Earned value progress measurement
9	none of the above specifically
10	Line of Balance
11	not sure
12	Varies site to site

19. What techniques does your organisation use for minimising uncertainty in production processes? (multiple choice)

	Responses	Percent
None:	47	43.52%
First Run Studies:	13	12.04%
Plan-Do-Check-Act (PDCA):	42	38.89%
Pre-Fabrication Strategies:	23	21.3%
If other, please specify:	12	11%
Total Responded to this question:	108	77.14%
Total who skipped this question:	32	22.86%
Total:	140	100%

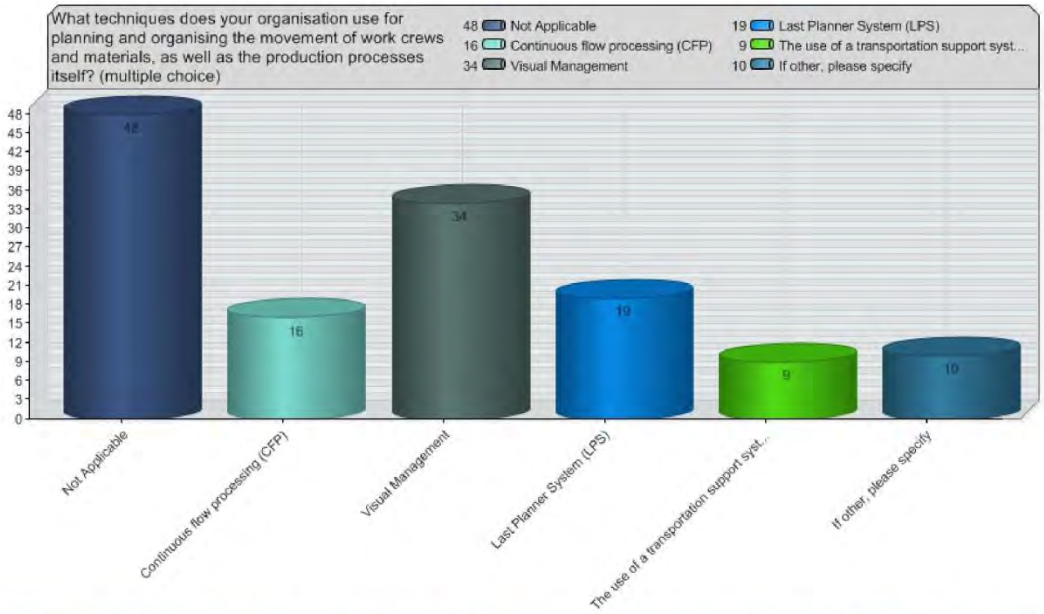


19. What techniques does your organisation use for minimising uncertainty in production processes? (multiple choice)

Response	Comments
1	We use gateways
2	see previous comment
3	Don't know
4	Risk Management Schedules.
5	Prototypes
6	Production is not my main concern
7	Happens on an adhoc basis. First issue drawings are issued to contractor. They comment. We revise. Meetings are held to revolve design issues (often once a problem is detected on site.)
8	dont know
9	N/A
10	NB: pre-fabrication is only really possible when production reliability improves - not the other way round as you question implies.
11	not sure
12	???

20. What techniques does your organisation use for planning and organising the movement of work crews and materials, as well as the production processes itself? (multiple choice)

	Responses	Percent
Not Applicable:	48	45.28%
Continuous flow processing (CFP):	16	15.09%
Visual Management:	34	32.08%
Last Planner System (LPS):	19	17.92%
The use of a transportation support system integrating horizontal and vertical movements (e.g. Crane):	9	8.49%
If other, please specify:	10	9%
Total Responded to this question:	106	75.71%
Total who skipped this question:	34	24.29%
Total:	140	100%

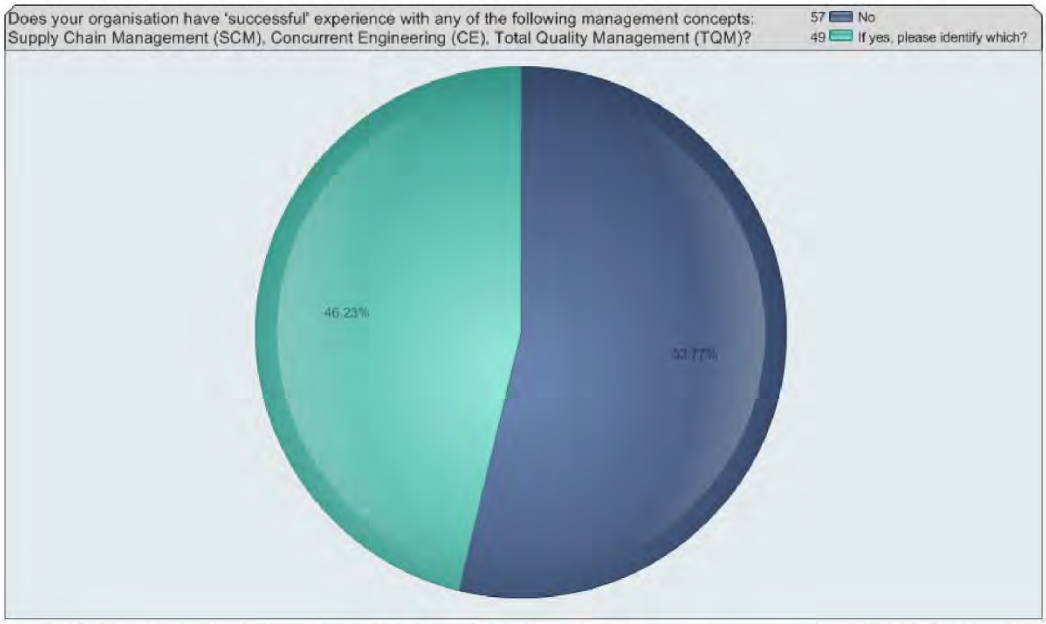


20. What techniques does your organisation use for planning and organising the movement of work crews and materials, as well as the production processes itself? (multiple choice)

Response	Comments
1	Terminology in construction can be different which may confuse, eg Hook time analysis, Logistics planning
2	line of balance, VDC, value stream mapping
3	We also use Masternaut and I am currently analysing our true capability
4	Traditional management techniques and project updates at bi-weekly/monthly intervals
5	"git 'er done"
6	Logistics Plan
7	Use dedicated logistics contractor
8	not sure
9	not sure about that
10	Prima Vera

21. Does your organisation have 'successful' experience with any of the following management concepts: Supply Chain Management (SCM), Concurrent Engineering (CE), Total Quality Management (TQM)?

	Responses	Percent
No:	57	53.77%
If yes, please identify which?:	49	46.23%
Total Responded to this question:	106	75.71%
Total who skipped this question:	34	24.29%
Total:	140	100%



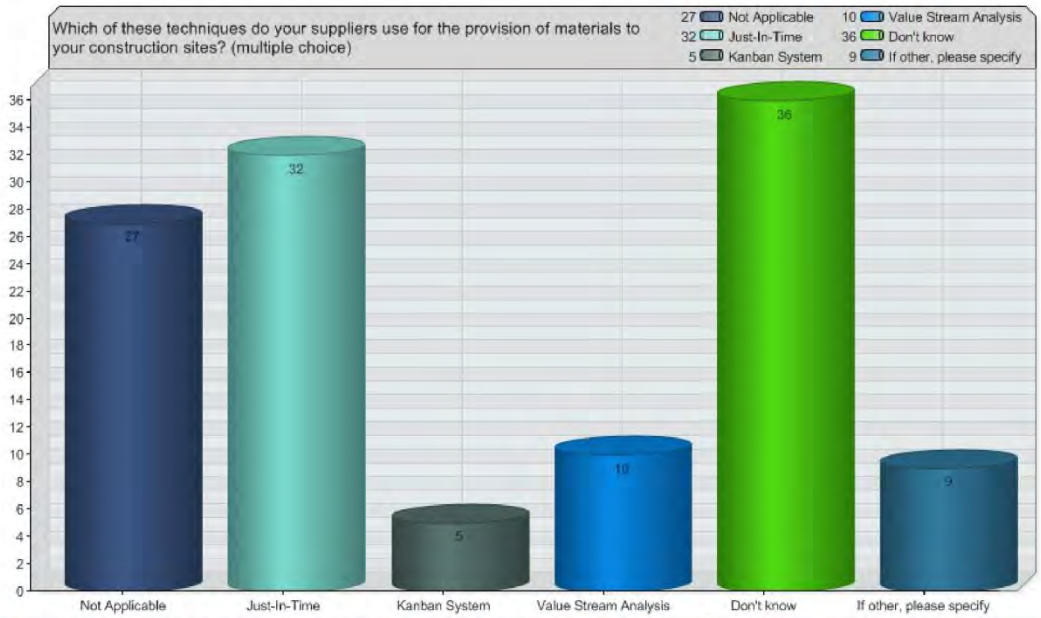
21. Does your organisation have 'successful' experience with any of the following management concepts: Supply Chain Management (SCM), Concurrent Engineering (CE), Total Quality Management (TQM)?

Response	Comments
1	SCM & TQM
2	All contractors will say they implement SCM
3	Don't know
4	SCM, TQM, CE
5	SCM
6	Total Quality Management
7	TQM
8	TQM
9	SCM
10	We are working on project that are utilising what could be described as supply chain management. As they are in progress "sucess" can nonly be determined upon completion.
11	SCM & TQM
12	SCM and TQM
13	SCM, TQM
14	SCM and TQM
15	Supply chain management
16	tqm
17	SCM and TQM
18	both
19	scm
20	Sqm, tqm

21	SCM
22	SCM TQM
23	scm
24	SCM
25	TQM (to some extent)
26	SCM
27	TQM, Value Stream Mapping and Blueprinting
28	SCM and TQM
29	SCM
30	SCM
31	SCM. TQM
32	SCM and TQM
33	TQM - ISYS
34	tqm
35	Supply Chain Management (SCM), Concurrent Engineering (CE)
36	scm and tqm
37	SCM
38	SCM
39	SCM, TQM
40	SCM and TQM
41	Supply chain management
42	TQM
43	scm
44	we do have a special team who check the quality of the project
45	TQM,SCM
46	SCM, TQM
47	TQM
48	TQM
49	tqm

22. Which of these techniques do your suppliers use for the provision of materials to your construction sites? (multiple choice)

	Responses	Percent
Not Applicable:	27	25.47%
Just-In-Time:	32	30.19%
Kanban System:	5	4.72%
Value Stream Analysis:	10	9.43%
Don't know:	36	33.96%
If other, please specify:	9	8%
Total Responded to this question:	106	75.71%
Total who skipped this question:	34	24.29%
Total:	140	100%

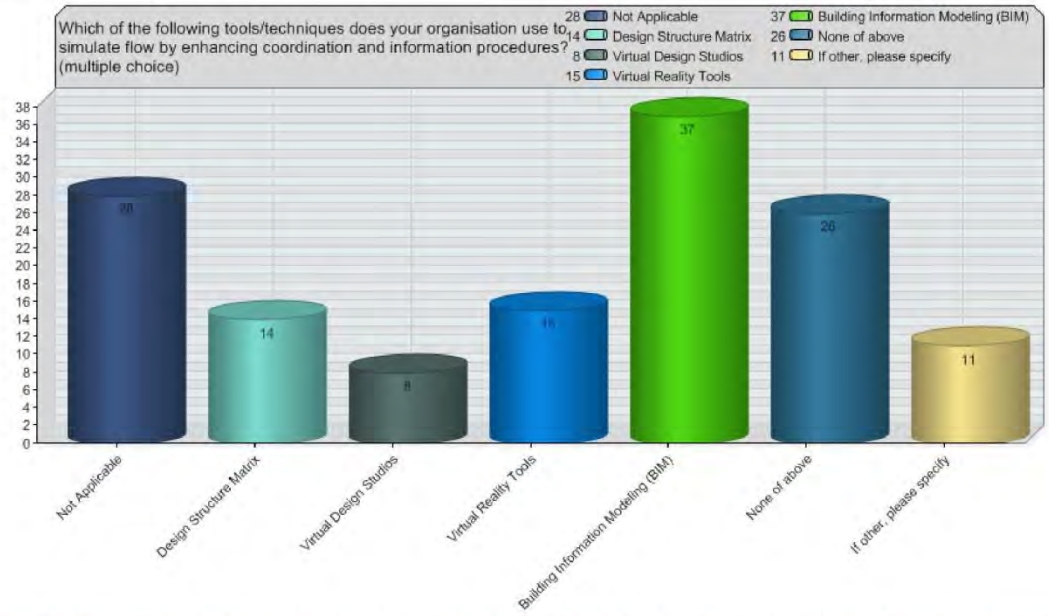


22. Which of these techniques do your suppliers use for the provision of materials to your construction sites? (multiple choice)

Response	Comments
1	Procurement made to a defined procurement schedule
2	supply to schedule
3	Still in the process of aligning the suppliers with organizations Lean strategy
4	usually as and when required
5	Traditional(wasteful)
6	JUST IN CASE
7	our Logistics Plan, Last Planner
8	Various there are many suppliers and many methods, we try to regulate this using a logistics contractor.
9	Wouldn't call it "Just-in-time" it's not as formalised as that, however materials are ordered in accordance with our project team's programmes.

23. Which of the following tools/techniques does your organisation use to simulate flow by enhancing coordination and information procedures? (multiple choice)

	Responses	Percent
Not Applicable:	28	26.67%
Design Structure Matrix:	14	13.33%
Virtual Design Studios:	8	7.62%
Virtual Reality Tools:	15	14.29%
Building Information Modeling (BIM):	37	35.24%
None of above:	26	24.76%
If other, please specify:	11	10%
Total Responded to this question:	105	75%
Total who skipped this question:	35	25%
Total:	140	100%

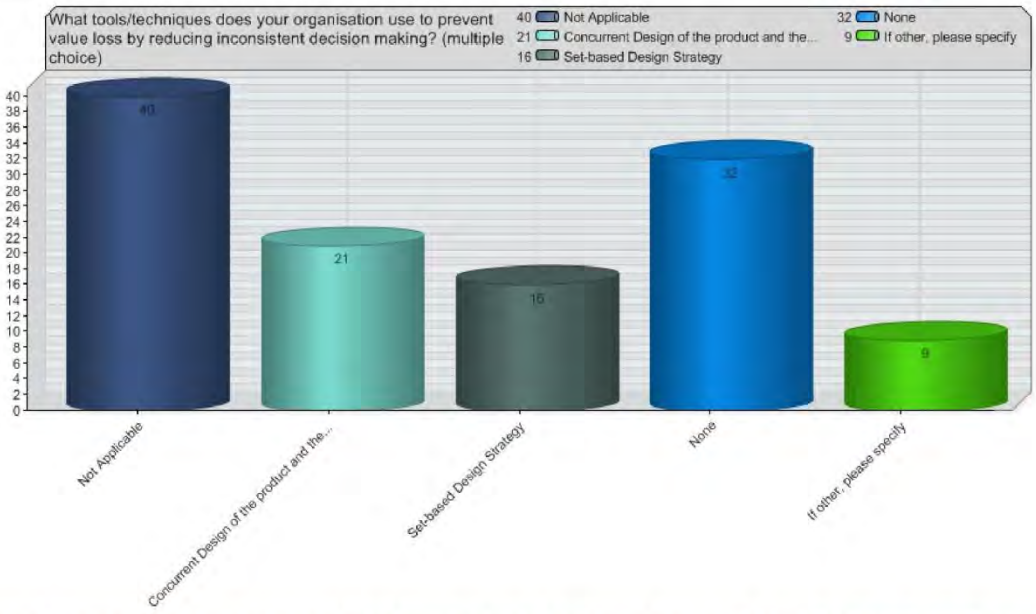


23. Which of the following tools/techniques does your organisation use to simulate flow by enhancing coordination and information procedures? (multiple choice)

Response	Comments
1	again different tools used by different sites
2	Don't know
3	SMED at the moment with plans to integrate Virtual Reality Tools through a real time reporting Management Information System
4	(We talk about using BIM but this is rarely used in practice.)
5	resource loaded CPM schedule
6	Daily Coordination Meetings followed by Lean Daily Management Meeting involving all
7	CAD
8	As a consultancy we do not use these across our portfolio
9	DSM only in Design + Last Planner,
10	Some limited BIM but not extensively
11	3D modelling

24. What tools/techniques does your organisation use to prevent value loss by reducing inconsistent decision making? (multiple choice)

	Responses	Percent
Not Applicable:	40	37.74%
Concurrent Design of the product and the process:	21	19.81%
Set-based Design Strategy:	16	15.09%
None:	32	30.19%
If other, please specify:	9	8%
Total Responded to this question:	106	75.71%
Total who skipped this question:	34	24.29%
Total:	140	100%

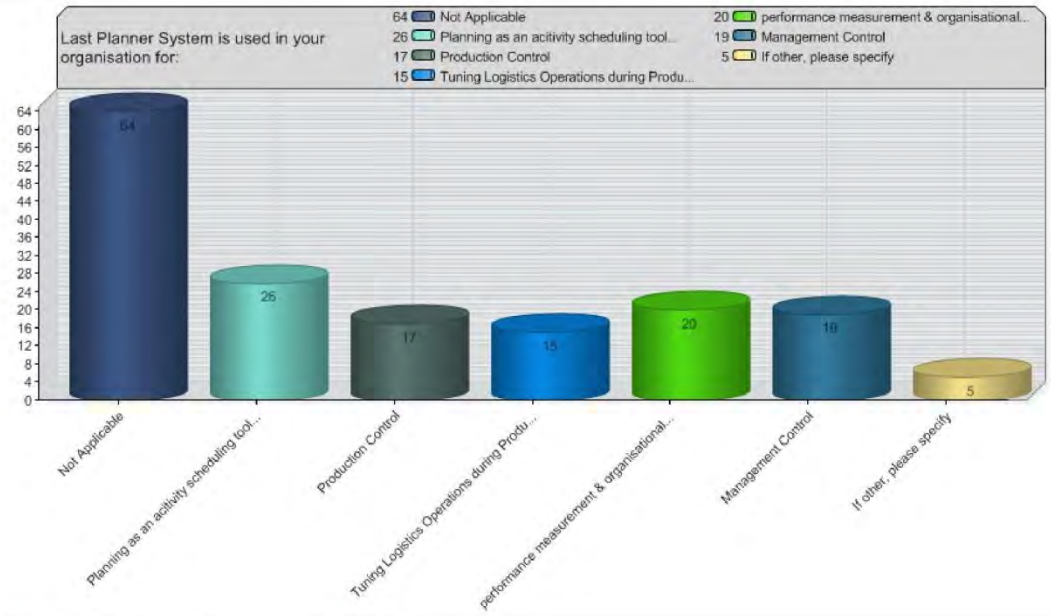


24. What tools/techniques does your organisation use to prevent value loss by reducing inconsistent decision making? (multiple choice)

Response	Comments
1	Design management
2	Don't know
3	(That I, as senior architect, am aware of.)
4	Project specific controls that deliver the Client's objectives
5	Size of organisation
6	Experience
7	all these in design + A3, Choosing by Advantages
8	not sure
9	Not sure

25. Last Planner System is used in your organisation for:

	Responses	Percent
Not Applicable:	64	60.95%
Planning as an acitivity scheduling tool:	26	24.76%
Production Control:	17	16.19%
Tuning Logistics Operations during Production:	15	14.29%
performance measurement & organisational learning:	20	19.05%
Management Control:	19	18.1%
If other, please specify:	5	4%
Total Responded to this question:	105	75%
Total who skipped this question:	35	25%
Total:	140	100%

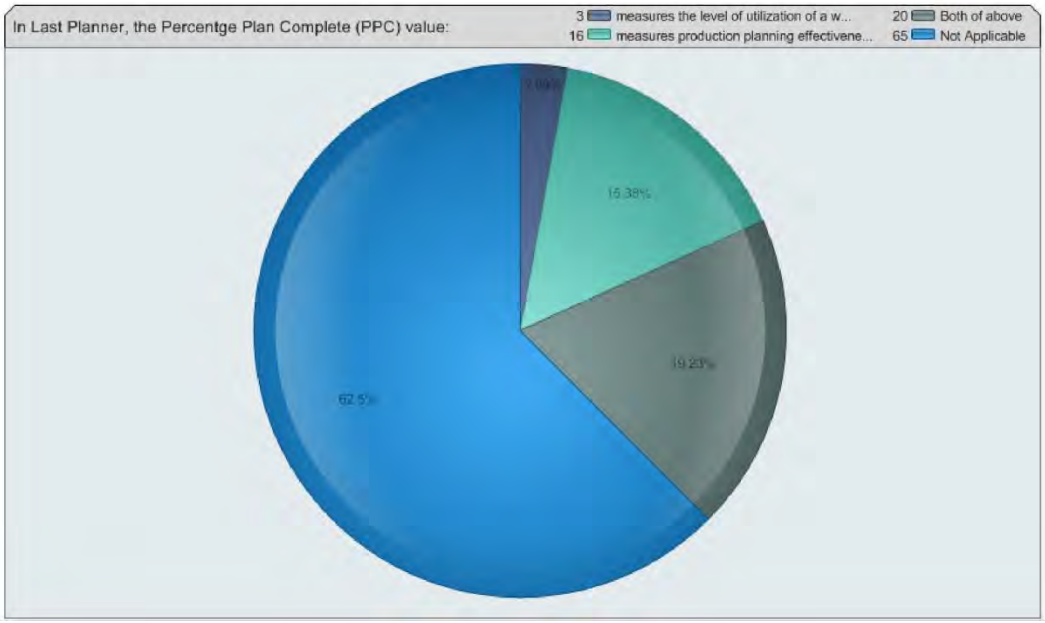


25. Last Planner System is used in your organisation for:

Response	Comments
1	Collaborative planning
2	Don't know
3	no
4	We do not use Last Planner system as our primary role is not consultany within the construction industry. We are aware of the tool and its application within the construction industry.
5	systematically making work ready commitment management production management, learning,

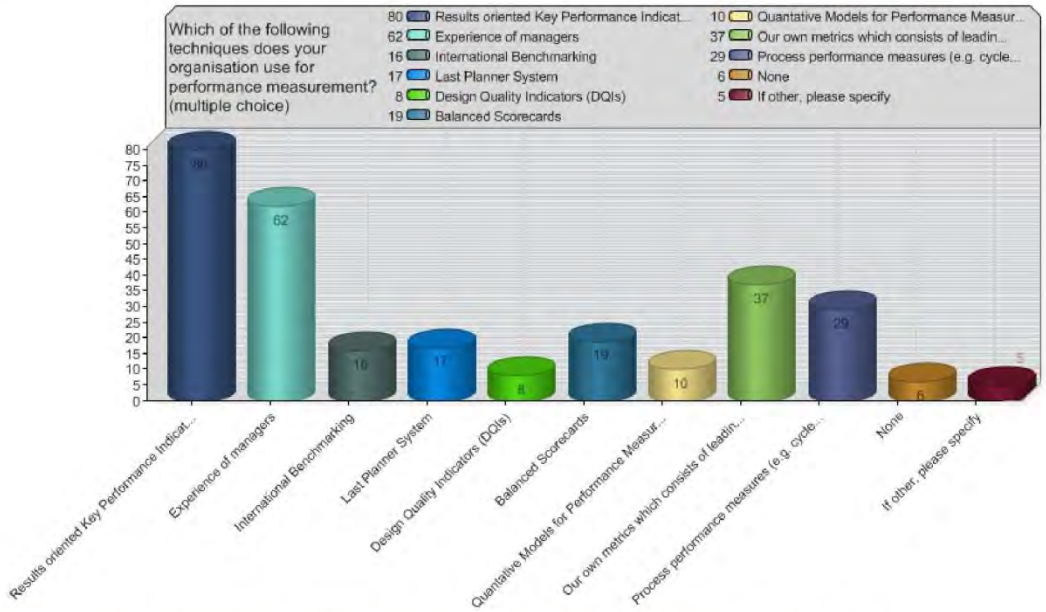
26. In Last Planner, the Percentge Plan Complete (PPC) value:

	Responses	Percent
measures the level of utilization of a work flow (efficiency).:	3	2.88%
measures production planning effectiveness and workflow reliability:	16	15.38%
Both of above:	20	19.23%
Not Applicable:	65	62.5%
Total Responded to this question:	104	74.29%
Total who skipped this question:	36	25.71%
Total:	140	100%



27. Which of the following techniques does your organisation use for performance measurement? (multiple choice)

	Responses	Percent
Results oriented Key Performance Indicators (KPIs), such as cost and time indicators:	80	74.77%
Experience of managers:	62	57.94%
International Benchmarking:	16	14.95%
Last Planner System:	17	15.89%
Design Quality Indicators (DQIs):	8	7.48%
Balanced Scorecards:	19	17.76%
Quantative Models for Performance Measurement Systems (QMPMS):	10	9.35%
Our own metrics which consists of leading indicators aiming to give early warnings. It is also consistent with our buisness strategy:	37	34.58%
Process performance measures (e.g. cycle time, Rework, waste, etc):	29	27.1%
None:	6	5.61%
If other, please specify:	5	4%
Total Responded to this question:	107	76.43%
Total who skipped this question:	33	23.57%
Total:	140	100%



27. Which of the following techniques does your organisation use for performance measurement? (multiple choice)

Response	Comments
1	External consultants, Nisus, to carry out independent client surveys and iterviews
2	These are meausred in some areas and I plan to incorporate a number of these so the business can effectively make decisions in order to continuously improve
3	Bespoke GFORM system
4	Customer Feedback
5	Client satisfaction and repeat bookings

28. Please score out of 10 each of the following 'Non - Financial' performance measures, according to their importance (10 being the most important and 1 being the least important).

	Score out of 10 according to importance	Total
Quality:	107(100%)	107
Safety:	107(100%)	107
Client/Customer satisfaction:	107(100%)	107
Functionality:	107(100%)	107
Planning Efficiency:	107(100%)	107
Team Performance:	107(100%)	107
Productivity:	107(100%)	107

Total Responded to this question:	107	76.43%
Total who skipped this question:	33	23.57%
Total:	140	100%

Graph/Chart function not relevant for this question type.

Quality	Safety	Client satisfaction	Functionality	Planning efficiency	Team performance	Productivity
9.00	9.00	9.00	8.00	9.00	9.00	9.00
10.00	10.00	10.00	1.00	1.00	1.00	1.00
10.00	10.00	10.00	8.00	8.00	7.00	7.00
9.00	10.00	10.00	9.00	9.00	7.00	9.00
9.00	10.00	10.00	9.00	8.00	8.00	8.00
10.00	10.00	10.00	8.00	9.00	10.00	7.00
10.00	10.00	10.00	8.00	8.00	10.00	10.00
8.00	10.00	9.00	7.00	4.00	6.00	5.00
9.00	10.00	10.00	9.00	8.00	8.00	8.00
10.00	10.00	10.00	10.00	10.00	10.00	10.00
8.00	8.00	10.00	7.00	6.00	9.00	8.00
10.00	10.00	10.00	10.00	10.00	10.00	10.00
10.00	10.00	10.00	10.00	10.00	10.00	10.00
10.00	10.00	10.00	9.00	9.00	9.00	9.00
10.00	10.00	10.00	10.00	8.00	8.00	10.00
8.00	10.00	10.00	8.00	7.00	7.00	7.00
7.00	10.00	9.00	8.00	4.00	5.00	6.00
9.00	10.00	9.00	10.00	9.00	9.00	9.00
10.00	10.00	10.00	9.00	10.00	10.00	9.00
8.00	8.00	10.00	8.00	9.00	9.00	9.00
9.00	10.00	10.00	6.00	7.00	7.00	7.00
10.00	10.00	10.00	10.00	10.00	10.00	8.00
9.00	10.00	7.00	4.00	5.00	6.00	8.00
8.00	10.00	9.00	4.00	7.00	6.00	5.00
10.00	10.00	10.00	10.00	10.00	10.00	10.00
7.00	10.00	9.00	4.00	5.00	6.00	8.00
10.00	10.00	8.00	8.00	8.00	8.00	8.00
9.00	10.00	9.00	8.00	7.00	5.00	7.00
8.00	10.00	5.00	5.00	6.00	5.00	5.00
10.00	10.00	10.00	8.00	8.00	9.00	9.00

10.00	10.00	10.00	10.00	10.00	10.00	10.00
10.00	6.00	9.00	5.00	7.00	4.00	8.00
10.00	10.00	10.00	10.00	10.00	9.00	9.00
9.00	9.00	10.00	9.00	9.00	7.00	9.00
8.00	8.00	9.00	7.00	7.00	10.00	10.00
9.00	9.00	9.00	8.00	9.00	9.00	9.00
8.00	10.00	10.00	7.00	6.00	6.00	7.00
9.00	10.00	9.00	8.00	7.00	8.00	10.00
7.00	10.00	8.00	5.00	5.00	5.00	7.00
7.00	9.00	10.00	10.00	9.00	9.00	10.00
8.00	10.00	10.00	8.00	8.00	7.00	9.00
8.00	10.00	8.00	8.00	4.00	5.00	9.00
9.00	10.00	10.00	7.00	8.00	8.00	8.00
2.00	6.00	3.00	5.00	7.00	4.00	1.00
8.00	8.00	10.00	10.00	6.00	8.00	8.00
9.00	10.00	8.00	7.00	7.00	7.00	8.00
10.00	10.00	10.00	8.00	8.00	8.00	8.00
10.00	10.00	10.00	7.00	9.00	9.00	9.00
10.00	10.00	10.00	10.00	10.00	10.00	10.00
8.00	10.00	9.00	6.00	7.00	5.00	4.00
9.00	10.00	10.00	8.00	9.00	8.00	8.00
10.00	10.00	10.00	1.00	8.00	8.00	8.00
10.00	8.00	10.00	7.00	4.00	6.00	5.00
7.00	10.00	10.00	10.00	10.00	8.00	5.00
8.00	10.00	8.00	8.00	7.00	8.00	10.00
7.00	10.00	7.00	7.00	6.00	7.00	7.00
10.00	10.00	10.00	8.00	9.00	9.00	8.00
10.00	10.00	10.00	7.00	8.00	9.00	7.00
1.00	1.00	10.00	1.00	8.00	10.00	5.00
10.00	10.00	8.00	7.00	5.00	7.00	7.00
10.00	10.00	10.00	10.00	10.00	10.00	10.00
9.00	10.00	10.00	7.00	7.00	8.00	9.00
10.00	10.00	10.00	10.00	10.00	10.00	10.00
7.00	10.00	9.00	4.00	6.00	8.00	5.00
9.00	10.00	8.00	8.00	6.00	6.00	7.00
8.00	10.00	9.00	4.00	5.00	7.00	6.00
10.00	9.00	10.00	9.00	9.00	8.00	9.00
10.00	10.00	8.00	8.00	10.00	10.00	10.00
10.00	10.00	10.00	9.00	7.00	9.00	10.00
7.00	10.00	10.00	9.00	7.00	7.00	8.00
10.00	10.00	10.00	6.00	8.00	7.00	8.00
8.00	10.00	7.00	8.00	6.00	6.00	5.00
10.00	10.00	10.00	10.00	10.00	10.00	10.00
10.00	10.00	8.00	8.00	8.00	8.00	8.00
10.00	7.00	10.00	8.00	8.00	8.00	8.00
3.00	10.00	7.00	5.00	3.00	5.00	5.00
9.00	9.00	9.00	9.00	9.00	9.00	8.00
10.00	10.00	10.00	10.00	10.00	10.00	10.00
7.00	10.00	9.00	5.00	4.00	6.00	8.00
7.00	10.00	8.00	8.00	8.00	9.00	9.00

9.00	10.00	9.00	9.00	9.00	9.00	8.00
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7.00	8.00	8.00	8.00	5.00	7.00	3.00
10.00	9.00	10.00	9.00	8.00	8.00	8.00
8.00	8.00	10.00	9.00	7.00	7.00	7.00
8.00	8.00	10.00	10.00	8.00	8.00	8.00
9.00	10.00	9.00	8.00	10.00	8.00	8.00
9.00	10.00	10.00	9.00	9.00	9.00	9.00
10.00	10.00	9.00	8.00	7.00	7.00	8.00
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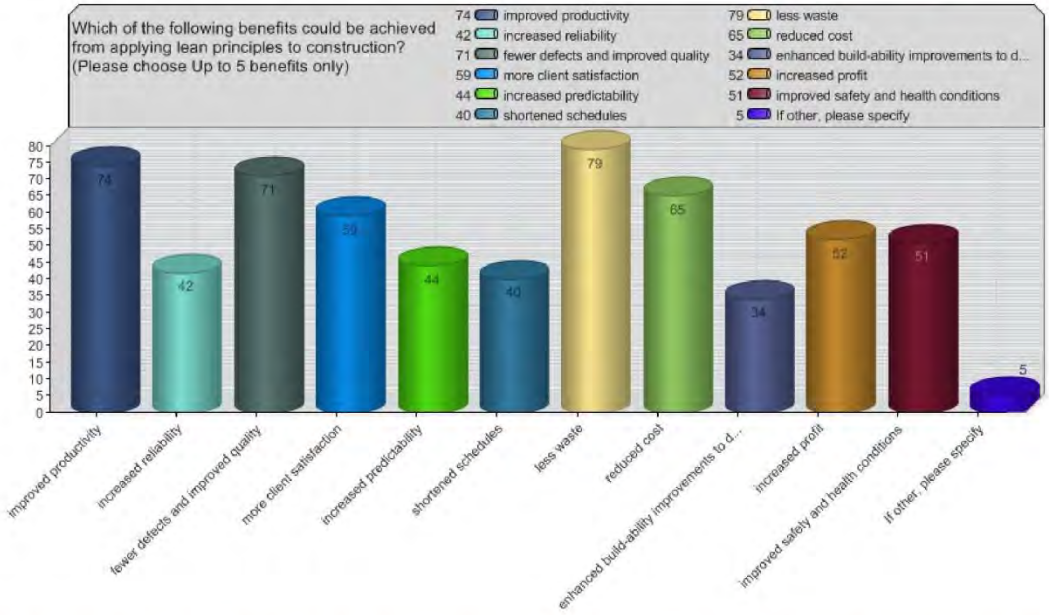
10.00	10.00	10.00	10.00	10.00	10.00	8.00
8.00	10.00	9.00	7.00	4.00	5.00	6.00
9.00	10.00	8.00	9.00	9.00	9.00	9.00
6.00	1.00	5.00	7.00	5.00	5.00	9.00
8.00	10.00	9.00	6.00	5.00	5.00	4.00
5.00	10.00	9.00	4.00	7.00	8.00	8.00
8.00	9.00	8.00	8.00	8.00	6.00	6.00
10.00	10.00	10.00	8.00	8.00	9.00	8.00
10.00	10.00	10.00	2.00	10.00	8.00	3.00
10.00	10.00	8.00	8.00	7.00	7.00	9.00
10.00	10.00	5.00	5.00	5.00	10.00	5.00

29.
Which of the following benefits could be achieved from applying lean principles to construction? (Please choose Up to 5 benefits only)

	Responses	Percent
improved productivity:	74	70.48%
increased reliability:	42	40%
fewer defects and improved quality:	71	67.62%
more client satisfaction:	59	56.19%
increased predictability:	44	41.9%
shortened schedules:	40	38.1%
less waste:	79	75.24%
reduced cost:	65	61.9%
enhanced build-ability improvements to design:	34	32.38%
increased profit:	52	49.52%
improved safety and health conditions:	51	48.57%
If other, please specify:	5	4%
Total Responded to this question:	105	75%
Total who skipped this question:	35	25%
Total:	140	100%



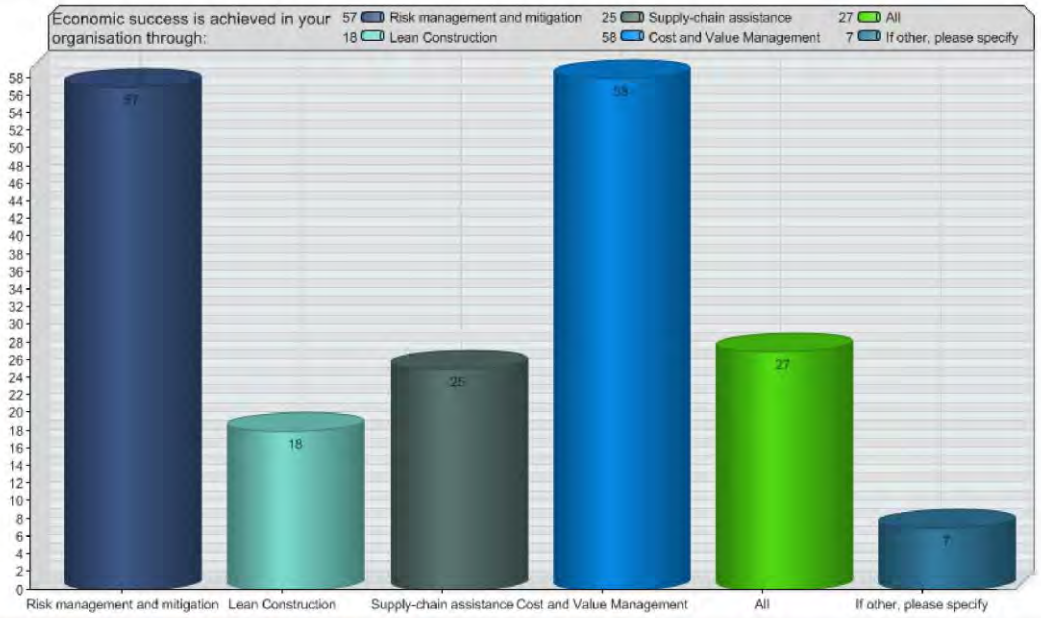
29.
Which of the following benefits could be achieved from applying lean principles to construction? (Please choose Up to 5 benefits only)

Response	Comments
1	collaboration between SC members
2	Positive recognition, increased innovation, more workplace satisfaction and pride
3	(I would select all of the aove if given the option)

4	they all can be achieved - why restrict to 5?
5	Longterm financial benefits,not necessarily shortterm profit

30. Economic success is achieved in your organisation through:

	Responses	Percent
Risk management and mitigation:	57	54.29%
Lean Construction:	18	17.14%
Supply-chain assistance:	25	23.81%
Cost and Value Management:	58	55.24%
All:	27	25.71%
If other, please specify:	7	6%
Total Responded to this question:	105	75%
Total who skipped this question:	35	25%
Total:	140	100%

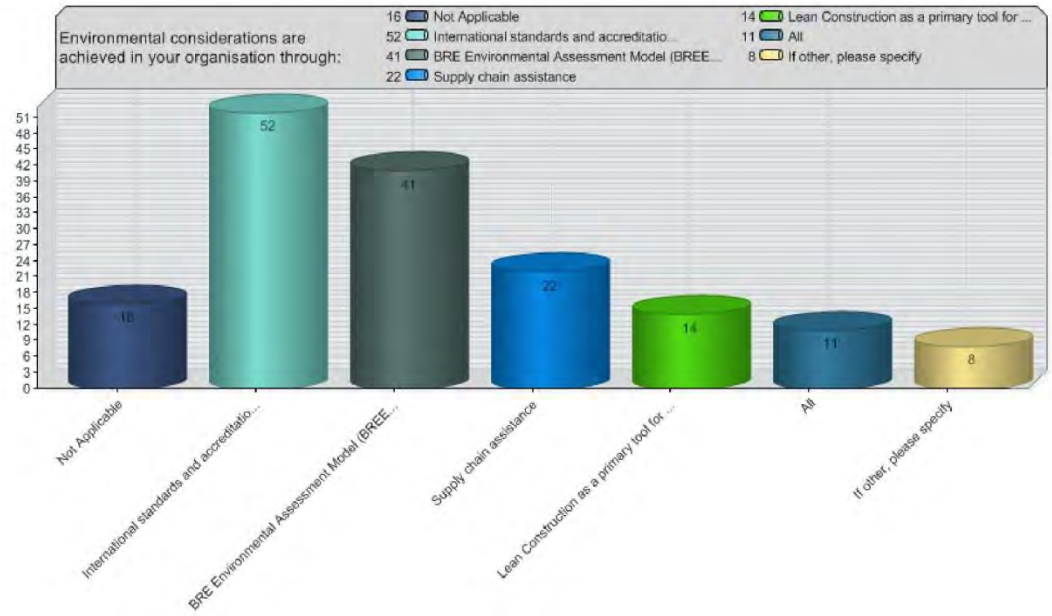


30. Economic success is achieved in your organisation through:

Response	Comments
1	Don't know
2	However this again is patchy around the whole organisation
3	Market strategy, sales process success, pricing strategy success, employee engagement, reputation management
4	Economic success is not being achieved a present. (One wonders how these tools could help.)
5	collaborative risk management particularly collaboration learning
6	working hard and long into the night!!!
7	Satisfactory Dimensional Control and minimal non conformancy

31. Environmental considerations are achieved in your organisation through:

	Responses	Percent
Not Applicable:	16	15.24%
International standards and accreditation, such as the ISO 14001:	52	49.52%
BRE Environmental Assessment Model (BREEAM):	41	39.05%
Supply chain assistance:	22	20.95%
Lean Construction as a primary tool for reducing physical waste:	14	13.33%
All:	11	10.48%
If other, please specify:	8	7%
Total Responded to this question:	105	75%
Total who skipped this question:	35	25%
Total:	140	100%

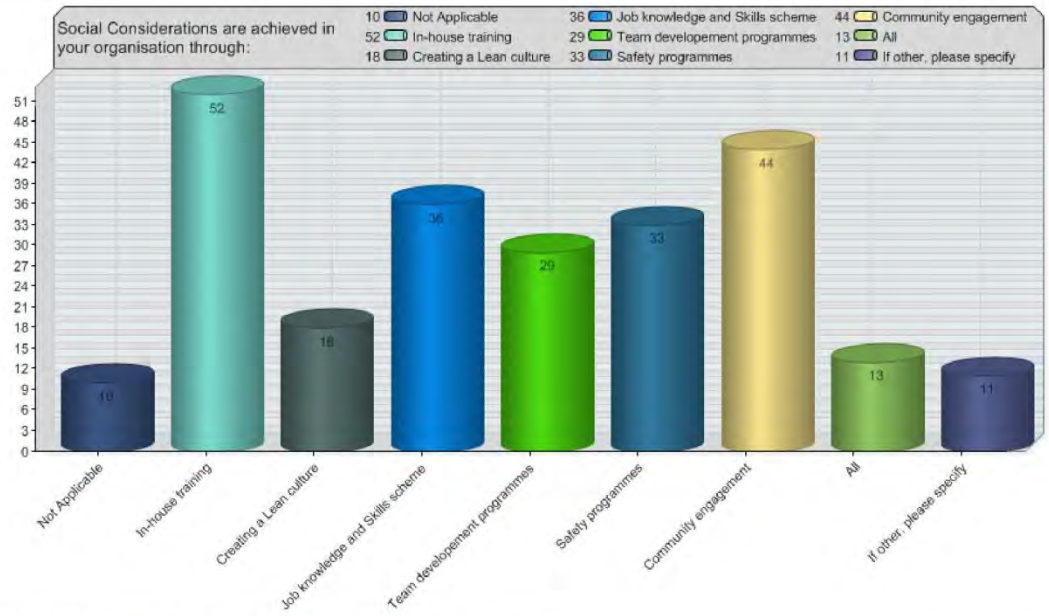


31. Environmental considerations are achieved in your organisation through:

Response	Comments
1	Don't know
2	LEED
3	Cost management - in general, managing to a low cost base means use of less natural resources. Travel costs being a prime example.
4	A consideration of Environmental issues though no formal systems in place (as yet)
5	Customer-driven LEED programs
6	The Highways Agency has an Environmental team looking at a range of environmental issues related to our highways schemes (protected species, air and noise quality, waste etc) and a Sustainability team reducing carbon in supply chain activities and other Highways Agency activities
7	good thinking in design
8	Passivhaus standard

32. Social Considerations are achieved in your organisation through:

	Responses	Percent
Not Applicable:	10	9.35%
In-house training:	52	48.6%
Creating a Lean culture:	18	16.82%
Job knowledge and Skills scheme:	36	33.64%
Team developement programmes:	29	27.1%
Safety programmes:	33	30.84%
Community engagement:	44	41.12%
All:	13	12.15%
If other, please specify:	11	10%
Total Responded to this question:	107	76.43%
Total who skipped this question:	33	23.57%
Total:	140	100%

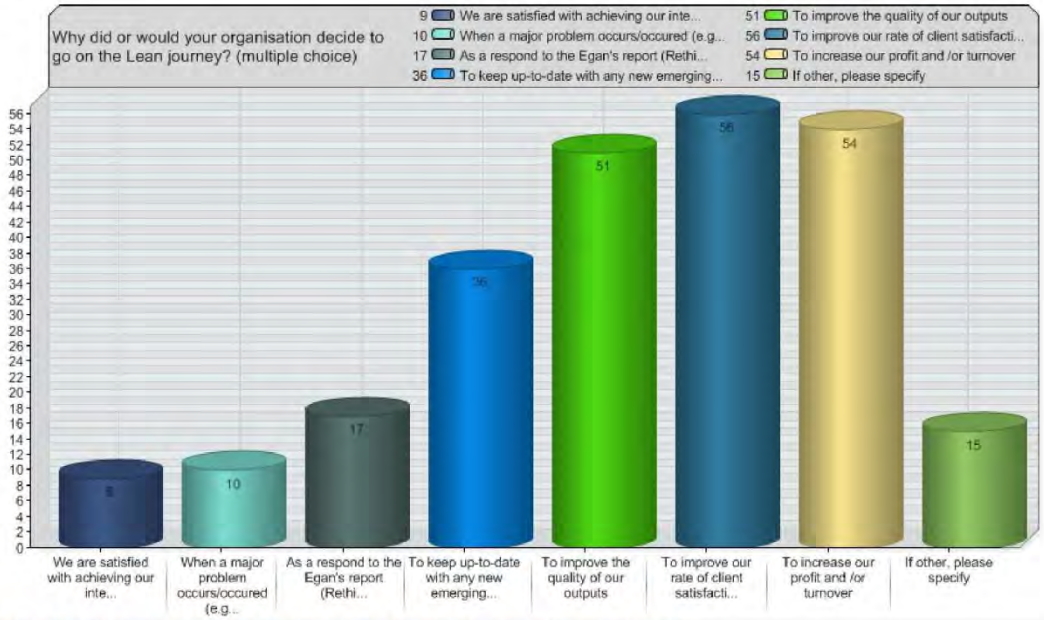


32. Social Considerations are achieved in your organisation through:

Response	Comments
1	I'm not sure what you mean by social considerations - if you mean as part of CSR there is significant input into recruitment and training, use of local SME's and businesses as well as community engagement
2	Not sure what you mean.
3	Don't understand question
4	Corporate Social Responsibility
5	Making social outcomes a core part of business purpose as expressed in corporate vision and strategy design.
6	With regard t the above little/no consideration is given to social considerations.
7	Again a consideration of the issues without a formal policy
8	Nost of the above but in an unplanned manner
9	CSCS, central support for community involvement and community support days where the whole organisation stops normal work and takes part in a local community day project
10	what do you mean by "social considerations"?
11	Defining work and leisure and not living to work

33. Why did or would your organisation decide to go on the Lean journey? (multiple choice)

	Responses	Percent
We are satisfied with achieving our intended objectives. No need to change:	9	8.74%
When a major problem occurs/occured (e.g global financial crisis):	10	9.71%
As a respond to the Egan's report (Rethinking Construction):	17	16.5%
To keep up-to-date with any new emerging management concepts:	36	34.95%
To improve the quality of our outputs:	51	49.51%
To improve our rate of client satisfaction:	56	54.37%
To increase our profit and /or turnover:	54	52.43%
If other, please specify:	15	14%
Total Responded to this question:	103	73.57%
Total who skipped this question:	37	26.43%
Total:	140	100%



33. Why did or would your organisation decide to go on the Lean journey? (multiple choice)

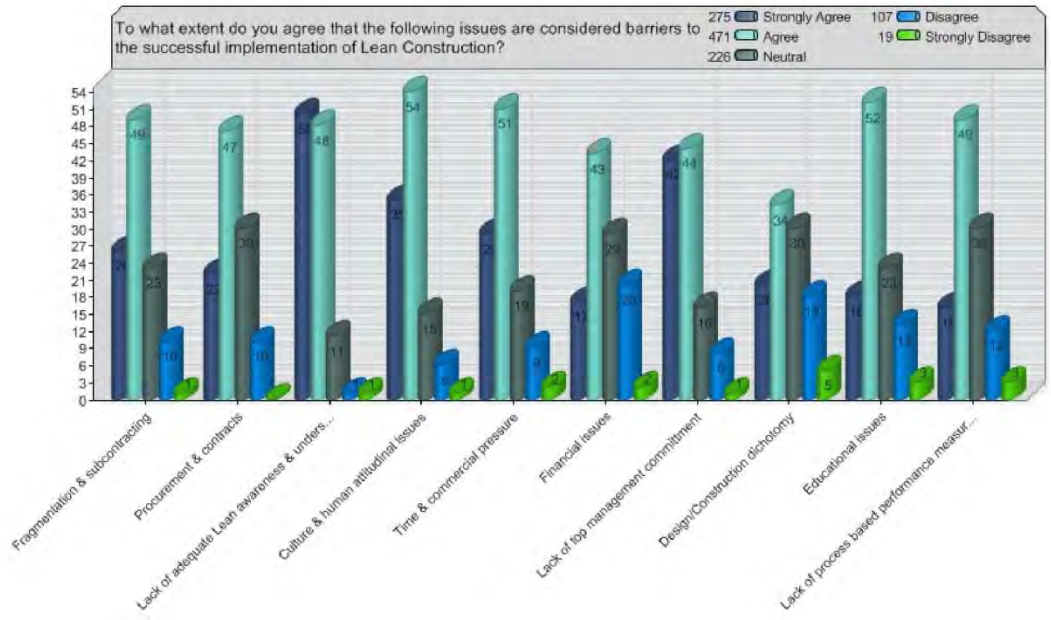
Response	Comments
1	Improve predictability of delivery and to support internal continuous improvement focus
2	Don't know
3	We have an 'islands of excellence' approach based upon client requirements, which (in my opinion) is not sufficient
4	Just to expand the client satisfaction - all stakeholders. Also, to gain a competetive edge
5	If clients want it
6	To reduce waste and therefore improve the social and environmental integrity of the organisation.
7	The organisation talks the talk when required but is not actively engaging with lean processes. I personally am interested in Lean C as a means of improving quality whilst reducing cost.
8	To improve the certainty of outcome
9	Not Applicable
10	They are not clued up enough to even think about lean procedures.
11	Making projects more profitable should be the prime aim, all other factors, e.g. client satisfaction, improve quality, improve HSE, etc are

	all objectives to achieve the main target, which is MORE RELIABLE FLOW OF MONEY.
12	I personally championed the measures in place .
13	to create safer operations to reduce stress on project managers
14	Journey not yet started!
15	Our experience working on the MOJ Framework

34. To what extent do you agree that the following issues are considered barriers to the successful implementation of Lean Construction?

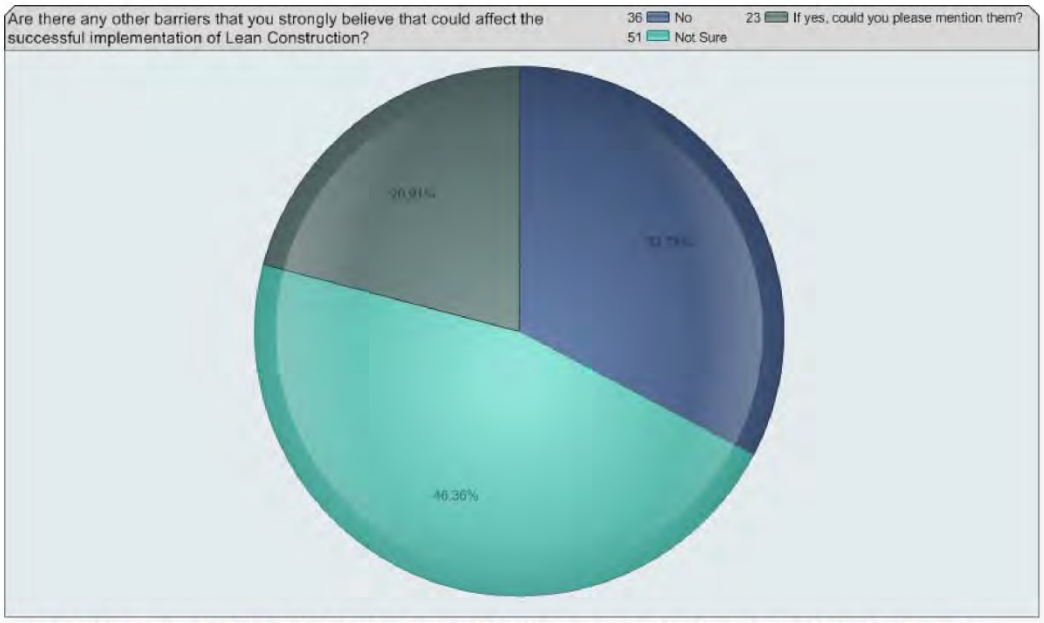
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total
Fragmentation & subcontracting:	26(23.85%)	49(44.95%)	23(21.1%)	10(9.17%)	1(0.92%)	109
Procurement & contracts:	22(20.18%)	47(43.12%)	30(27.52%)	10(9.17%)	0(0%)	109
Lack of adequate Lean awareness & understanding:	50(45.05%)	48(43.24%)	11(9.91%)	1(0.9%)	1(0.9%)	111
Culture & human attitudinal issues:	35(31.53%)	54(48.65%)	15(13.51%)	6(5.41%)	1(0.9%)	111
Time & commercial pressure:	29(26.36%)	51(46.36%)	19(17.27%)	9(8.18%)	2(1.82%)	110
Financial issues:	17(15.32%)	43(38.74%)	29(26.13%)	20(18.02%)	2(1.8%)	111
Lack of top management committment:	42(37.84%)	44(39.64%)	16(14.41%)	8(7.21%)	1(0.9%)	111
Design/Construction dichotomy:	20(18.69%)	34(31.78%)	30(28.04%)	18(16.82%)	5(4.67%)	107
Educational issues:	18(16.51%)	52(47.71%)	23(21.1%)	13(11.93%)	3(2.75%)	109
Lack of process based performance measurement systems:	16(14.55%)	49(44.55%)	30(27.27%)	12(10.91%)	3(2.73%)	110

Total Responded to this question:	111	79.29%
Total who skipped this question:	29	20.71%
Total:	140	100%



35. Are there any other barriers that you strongly believe that could affect the successful implementation of Lean Construction?

	Responses	Percent
No:	36	32.73%
Not Sure:	51	46.36%
If yes, could you please mention them?:	23	20.91%
Total Responded to this question:	110	78.57%
Total who skipped this question:	30	21.43%
Total:	140	100%



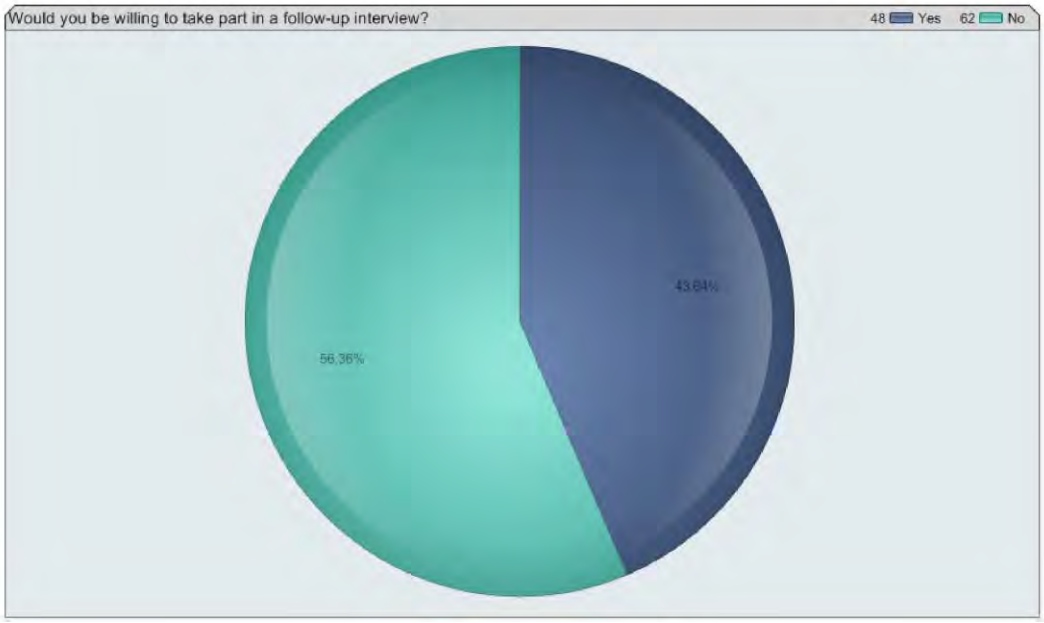
35. Are there any other barriers that you strongly believe that could affect the successful implementation of Lean Construction?

Response	Comments
1	Work Culture and education
2	Transparency of cost and value within the supply chain
3	Client knowledge and desire.
4	General conservatism and relectance to change
5	The lack of prioritising and tackling the critical issues first. This is a planning issue and in my experience before I have started a journey, people try to tackle every problem under one umbrella rather than in seperate projects depending on how critical or key they are to the performance of the business. Ego's and being scared of failure also play there part and a belief that it has to be expensive to change.
6	Belief in the principle that all projects are unique. Belief that construction is already efficient
7	Risk of delays and incorrect deliveries being made
8	Lack of systems thinking. QS's own agenda v PM agenda. They are trained to think this way.
9	The current economic climate, rather than encourage people to look at new/improved technolgies (ie take a risk), is more likely to make people revert to what they know and undertake operations the way they have always done in the past, but with more pressure to do it more economically or faster.
10	You've got to want too do it
11	This is applied mainly in big organizations, the huge gap between top management and the operational level management. For instance, in my organization the top management has done what they think right to be lean. However, this has not been transferred to the operations/project manager(s), it is very common to hear a PM repeating "I am a big fan of lean construction" without taking his/her statement to the commitment level.
12	Linked to the culture of the industry ... the lack of trust between supply chain members at all levels and the lack of back to back agreements
13	Client education and Client investment (time)
14	The main barriers to any improvement program are firstly is there pressure to change? Does the culture within the organisation encourage change or punish failure? Does the organisation provide the resources; time, finances etc. Once action plans of improvements are agreed is it measurable and supported through the organisations performance review process?
15	top level apathy and core culture are the two main stumbling blocks i encounter time and again.

16	the stories that celebrate the firefighters in our industry
17	Lack of publicity especially of success stories.
18	Management talking lean and then not doing anything about it when you offer suggestions.
19	Fast development can be barrier to quality and customer satisfaction. Developers looking to make money and move on to new projects. increase pressure from lenders make developer build less satisfactory dwelling.
20	Many Civil Engineering companies have multiple large and small/medium projects running concurrently. To implement lean consistently is a huge challenge.
21	Change, variability, and inter relation between activities in construction. Change management is a the main difference between construction and the regular manufacturing industry in Lean/Six Sigma.
22	old fashioned attitudes that prevent the industry from wanting to try anything new. most people actually think things finish on time etc.
23	Traditional skills based background of Construction is a major blocker

36. Would you be willing to take part in a follow-up interview?

	Responses	Percent
Yes:	48	43.64%
No:	62	56.36%
If Yes, please provide your contact details:	30	27.27%
Total Responded to this question:	110	78.57%
Total who skipped this question:	30	21.43%
Total:	140	100%



Note: The Author screened all of the respondents contact details due to privacy and confidentiality reasons (Author).

APPENDIX 13- SPSS STATISTICAL ANALYSIS

A13.1 Introduction

This chapter describes the tests that were used to determine the reliability of the data obtained from questions number 28 and 34, regarding performance indicators and barriers to LC respectively, which were (1) One Sample *t*-Test, and (2) Reliability Statistics (Reliability Test). Frequency variables and descriptive statistics will be provided, as well, where appropriate.

A13.2 Question 28: Non-Financial Performance Measures

(1) One Sample *t*-Test Results:

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Quality	107	8.7757	1.62706	.15729
Safety	107	9.5047	1.42996	.13824
Client Satisfaction	107	9.1495	1.27977	.12372
Functionality	107	7.6542	2.07457	.20056
Planning Efficiency	107	7.6075	1.92676	.18627
Team Performance	107	7.8037	1.77211	.17132
Productivity	107	7.7850	1.93297	.18687

One-Sample Test

	Test Value = 0					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Quality	55.792	106	.000	8.77570	8.4639	9.0876
Safety	68.755	106	.000	9.50467	9.2306	9.7787
Client Satisfaction	73.954	106	.000	9.14953	8.9042	9.3948
Functionality	38.165	106	.000	7.65421	7.2566	8.0518
Planning Efficiency	40.842	106	.000	7.60748	7.2382	7.9768
Team Performance	45.552	106	.000	7.80374	7.4641	8.1434
Productivity	41.661	106	.000	7.78505	7.4146	8.1555

❖ As can be seen all of the factors were significant as its *p* value was ≤0.05, and thus taken for further analysis.

(2) Reliability Statistics (Reliability Test)

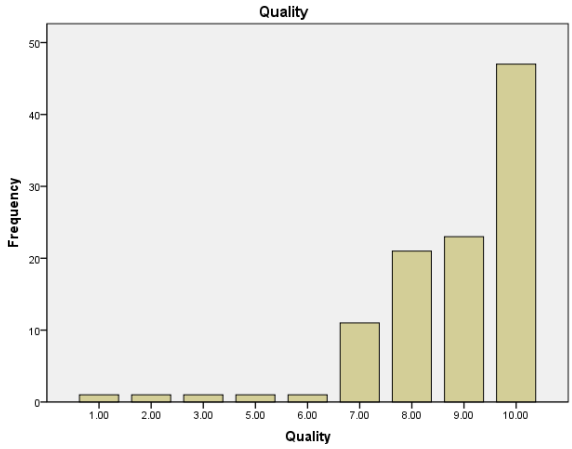
Reliability Statistics

Cronbach's Alpha	N of Items
.832	7

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Quality	49.5047	57.252	.576	.811
Safety	48.7757	65.647	.275	.849
Client Satisfaction	49.1308	62.285	.502	.823
Functionality	50.6262	50.991	.634	.802
Planning Efficiency	50.6729	51.128	.698	.789
Team Performance	50.4766	52.950	.697	.790
Productivity	50.4953	51.328	.686	.791

(3) Bar Charts


Quality
Frequency
Quality
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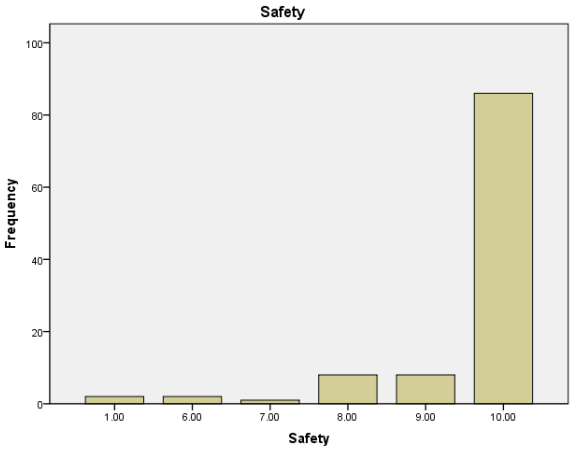
Safety
Frequency
Safety
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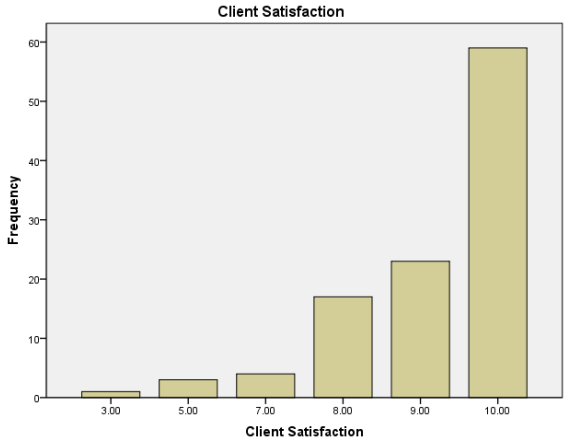
10.00


Client Satisfaction
Frequency
Client Satisfaction
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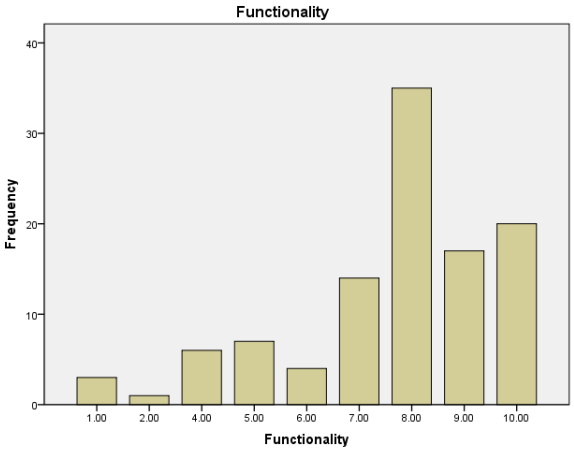
7.00
8.00
9.00
10.00


Functionality
Frequency
Functionality
1.00
2.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00


Planning Efficiency
Frequency
Planning Efficiency
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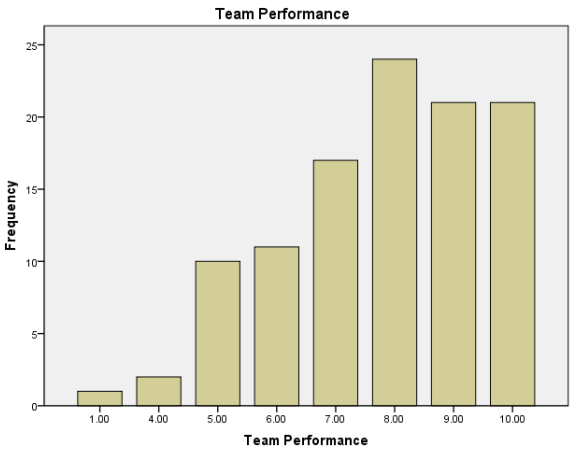
Team Performance
Frequency
Team Performance
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4.00
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7.00
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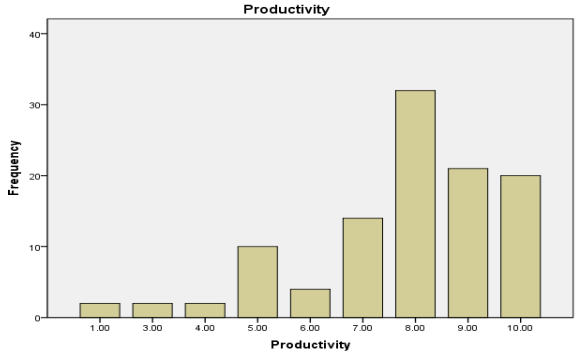
Productivity
Frequency
Productivity
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3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00

A13.2 Question 36: Barriers to Lean Construction

(1) One Sample *t*-Test Results:

One-Sample Test

	Test Value = 0					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Lower
Fragmentation & subcontracting	39.691	110	.000	3.76577	3.5777	3.9538
Procurement & contracts	40.900	110	.000	3.69369	3.5147	3.8727
Lack of adequate Lean awareness & understanding	59.674	110	.000	4.30631	4.1633	4.4493
Culture & human attitudinal issues	49.128	110	.000	4.04505	3.8819	4.2082
Time & commercial pressure	42.028	110	.000	3.89189	3.7084	4.0754
Financial issues	36.037	110	.000	3.47748	3.2862	3.6687
Lack of top management commitment	45.224	110	.000	4.06306	3.8850	4.2411
Design/Construction dichotomy	29.666	110	.000	3.34234	3.1191	3.5656
Educational issues	36.330	110	.000	3.58559	3.3900	3.7812
Lack of process based performance measurement systems	37.833	110	.000	3.54955	3.3636	3.7355

- As can be seen all of the factors were significant as its p value was ≤ 0.05, and thus taken for further analysis.

(2) Reliability Statistics (Reliability Test).

Reliability Statistics

Cronbach's Alpha	N of Items
.747	10

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Fragmentation & subcontracting	33.9550	23.952	.438	.722
Procurement & contracts	34.0270	25.699	.273	.745
Lack of adequate Lean awareness & understanding	33.4144	26.681	.252	.745
Culture & human attitudinal issues	33.6757	25.585	.331	.737
Time & commercial pressure	33.8288	25.034	.333	.737
Financial issues	34.2432	24.840	.332	.738
Lack of top management committment	33.6577	24.173	.448	.721
Design/Construction dichotomy	34.3784	21.910	.533	.705
Educational issues	34.1351	22.100	.620	.692
Lack of process based performance measurement systems	34.1712	23.525	.494	.713

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
37.7207	29.239	5.40735	10

(3) Frequency and descriptive statistics

Statistics

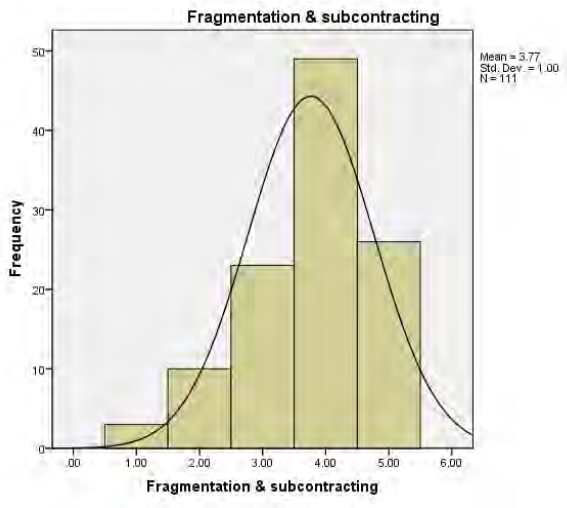
		Fragmentation & subcontracting	Procurement & contracts	Lack of adequate Lean awareness & understanding	Culture & human attitudinal issues
N	Valid	111	111	111	111
	Missing	0	0	0	0
Mean		3.7658	3.6937	4.3063	4.0450
Median		4.0000	4.0000	4.0000	4.0000
Mode		4.00	4.00	5.00	4.00
Std. Deviation		.99959	.95148	.76030	.86747
Variance		.999	.905	.578	.752
Skewness		-.735	-.508	-1.214	-.939
Std. Error of Skewness		.229	.229	.229	.229
Kurtosis		.197	-.050	2.428	.950
Std. Error of Kurtosis		.455	.455	.455	.455
Range		4.00	4.00	4.00	4.00

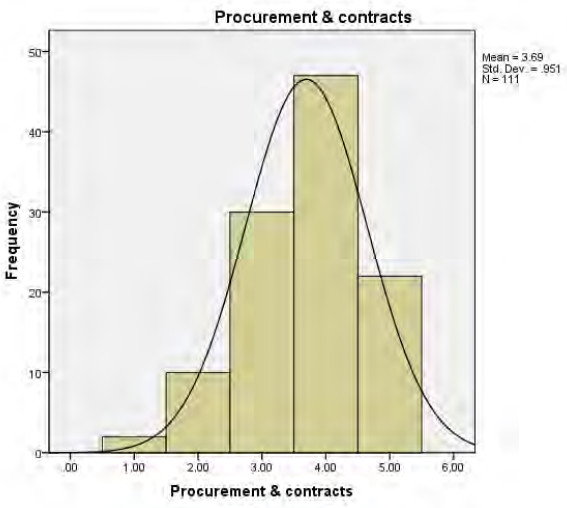
Statistics

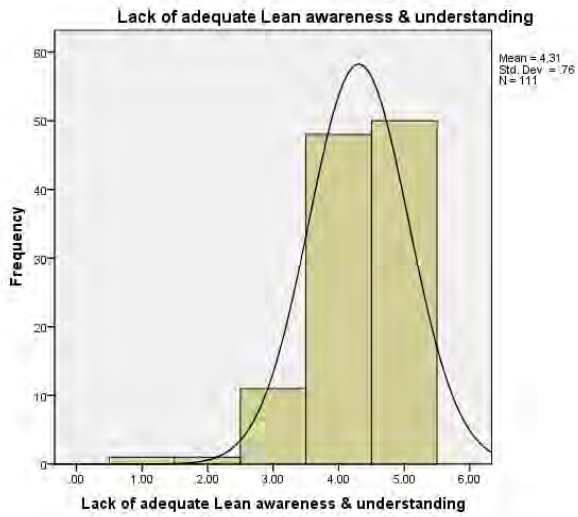
		Time & commercial pressure	Financial issues	Lack of top management commitment	Design/Construction dichotomy
N	Valid	111	111	111	111
	Missing	0	0	0	0
Mean		3.8919	3.4775	4.0631	3.3423
Median		4.0000	4.0000	4.0000	3.0000
Mode		4.00	4.00	4.00	4.00
Std. Deviation		.97562	1.01665	.94657	1.18702
Variance		.952	1.034	.896	1.409
Skewness		-.737	-.281	-.913	-.330
Std. Error of Skewness		.229	.229	.229	.229
Kurtosis		.421	-.687	.334	-.728
Std. Error of Kurtosis		.455	.455	.455	.455
Range		5.00	4.00	4.00	4.00

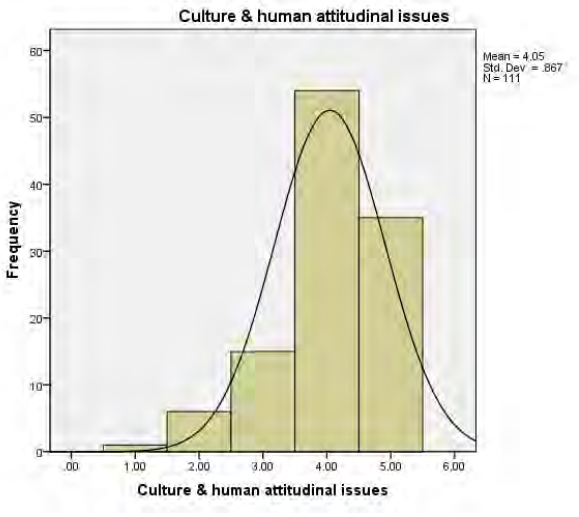
		Educational issues	Lack of process based performance measurement systems
N	Valid	111	111
	Missing	0	0
Mean		3.5856	3.5495
Median		4.0000	4.0000
Mode		4.00	4.00
Std. Deviation		1.03983	.98847
Variance		1.081	.977
Skewness		-.727	-.600
Std. Error of Skewness		.229	.229
Kurtosis		.053	.072
Std. Error of Kurtosis		.455	.455
Range		4.00	4.00

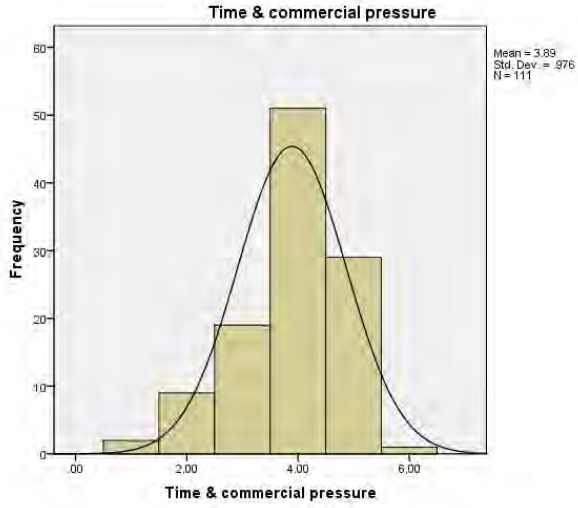
(4) Histograms

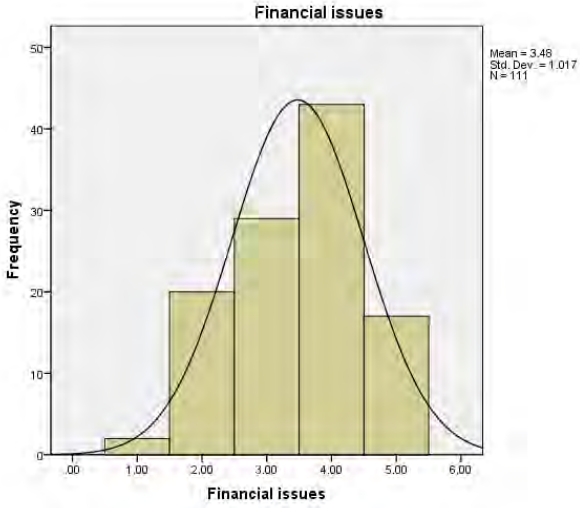


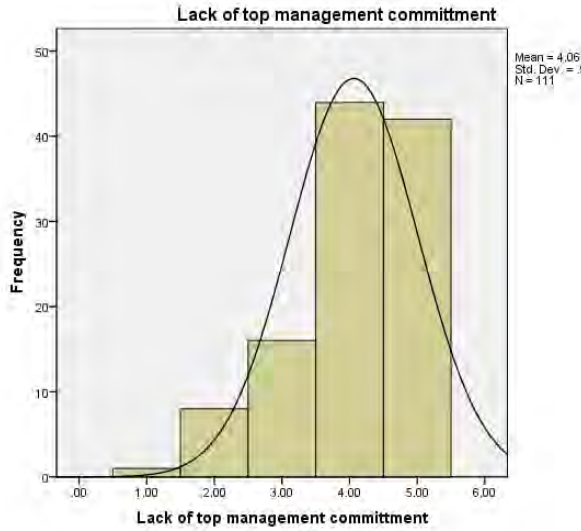


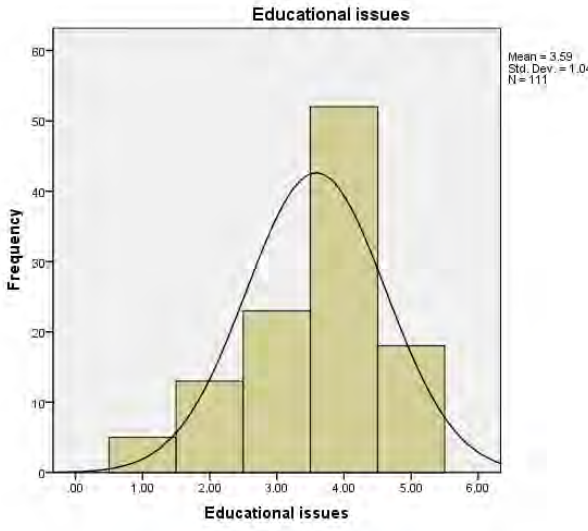

Lack of adequate Lean awareness & understanding
Mean = 4.31
Std. Dev. = .76
N = 111
Frequency
Lack of adequate Lean awareness & understanding

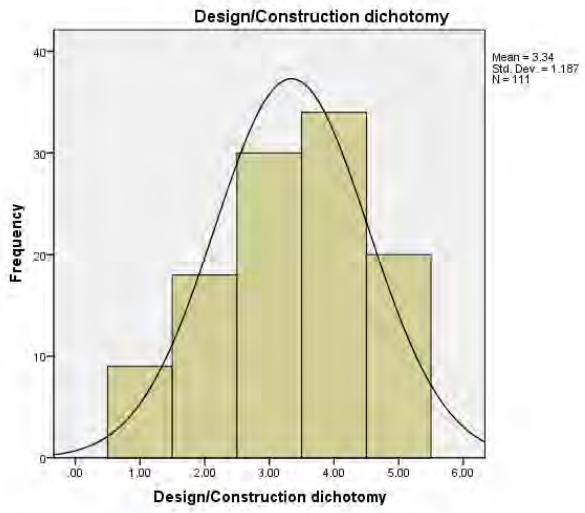

Culture & human attitudinal issues
Mean = 4.05
Std. Dev. = .867
N = 111
Frequency
Culture & human attitudinal issues

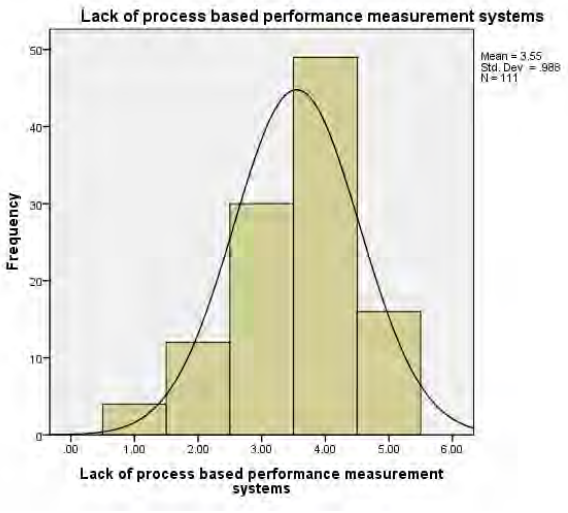

Time & commercial pressure
Mean = 3.89
Std. Dev. = .976
N = 111
Frequency
Time & commercial pressure


Financial issues
Mean = 3.48
Std. Dev. = 1.017
N = 111
Frequency
Financial issues


Lack of top management committment
Mean = 4.06
Std. Dev. = .947
N = 111
Frequency
Lack of top management committment


Educational issues
Mean = 3.59
Std. Dev. = 1.04
N = 111
Frequency
Educational issues


Design/Construction dichotomy
Mean = 3.34
Std. Dev. = 1.187
N = 111
Frequency
Design/Construction dichotomy


Lack of process based performance measurement systems
Mean = 3.55
Std. Dev. = .988
N = 111
Frequency
Lack of process based performance measurement systems

APPENDIX 14: FULL TRANSCRIPTS OF THE INTERVIEWS

A14.1 Semi Structured Interviews

Based on the outcomes of the questionnaire, particularly the identification of the significant barriers to the implementation of LC, a number of semi-structured interviews were conducted, in accordance with the procedures outlined in the research methodology chapter, to help the author to investigate deeper and achieve the objective of proposing a strategy for overcoming the barriers identified. All interviews were recorded after receiving written permission from the interviewees, as it is good research practice especially in case of semi-structured interviews (Thomas *et al.*, 2005). All interviews were asked two main questions: (1) to describe the nature of each of the three significant barriers identified (e.g. how it exists and why); and (2) to propose a strategy or provide recommendations for overcoming these barriers.

Note: The author faced some difficulties when carrying out the full transcript of the first interview which was conducted through internet webcam on Skype program, due to internet connection problems which affected the quality of the recorded sound. Therefore, there might be a few/minor mistakes with a limited amount of words & sentences.

A14.1.1 Interviewee number 1

This interview was conducted through internet webcam on Skype program. The interviewee is a Consultant/Author/Certified Professional Speaker in the construction industry, with more than 30 years of experience, and holding a bachelors degree in civil engineering. The full transcript is illustrated below.

Author: One question from the questionnaire asked participants to arrange barriers in order of their influence. The top three barriers identified were lack of adequate lean awareness and understanding, cultural barriers, and lack of top management commitment. This interview will consist of two parts; the first part will focus on the top three barriers, their nature, and

how and why they occur. The second part will focus on the strategy to overcome these problems. The principles of lean are simple so why is there an issue with understanding?

Interviewee: I think the problem is that people don't understand what lean is; which is a basic problem. We went through a process during the 70s, 80s and 90s, finding different ways of restructuring companies, to become leaner and leaner and leaner. Re-structuring companies meant getting rid of people. There was constant pressure to reduce the number of people. This is what lean was conceived as, a way to get rid of people. But what Tioni introduced into this concept, and I think this is absolutely critical, is that what they do is they don't eliminate people's jobs when...say you and I are working on a project. Only one needs to do it, so logic says one of us has to go. Tioni said that is ridiculous. If it's not costing me any more to have you do it by yourself, the second week I can go do something else and it's totally paid for because I'm not any worse off than I was yesterday. I'm only paying for two people but now I get more work done. It's about changing the mentality saying ok even if we're going to do something I don't know how to do right now they can afford to have me learn it. I can try to get invested in something new in the business because you're paying for it. Just because we're doing two peoples jobs I'm not an extra burden. We would have had to have hired someone else and put a cost on it. Now I'm no worse off. We reinvest that saving in growth. And I think once companies demonstrate that kind of a mentality I think it can change. This is part of the resistance. People feel it's a threat to their jobs. Once they realise it's not lean gets embraced. So when you have a system that works people are happy, they enjoy their job. It's a matter of getting through this culture and education of explaining really what it is. There's a problem when people misunderstand it, not when they understand it. I think this links to the second part about senior management.

Author: Is this due to fear? Fear of failure? Or just because they are not aware of the benefits and don't want to take any kind of risk?

Interviewee: Exactly. One of the other things we went through in the 60s, 70s, 80s was we tried these new gimmicks and most didn't work. Some weren't well thought out, not accurate. People didn't report what did happen when they did get results. For example, a guy says I painted my boat and the boat went up, but the boat went up because the water went up not because he painted it. In business that happens, people do things and then the business takes off; but it had no impact upon their business, it was because the economy took off so

everybody's business took off. So they write a book on this and it has no impact. That's part of the problem. So what happens is we go through these fads or concepts. And so what happens is people say why am I going to invest time and energy in this fad because in six months there will be another one. What that does to a certain extent is it makes it self-perpetuating. If nobody tries to implement the new ideas, they're not going to be successful and in six months they'll try something else. So it perpetuates and we get this thing. This is the other thing with lean; people don't understand it will work. One of the things you need to do is do small things in the beginning to get medium results. If you try to do big things that will take five years to turn this thing around, people aren't interested. But if we see medium results tomorrow, this isn't so bad. So I think it's partly how we approach it so it goes back to senior management. Senior management doesn't like they're committed, this is why it has to be senior management preaching it day in day out. Then you realise they're going to do this. But if management doesn't mention it and just says here you workers take care of this it says nobody cares and why am I wasting my time; so it's a big struggle.

Author: Yes. One of the participants commented that one of the problems is the traditional skills-based background of construction workers. So the skills that the construction workforce have are based on traditional skills, so this is a root problem .They are not innovative.

Interviewee: Right. The construction industry, historically, has employed people for brawn and not for their brain. Just do what you're told, this is the mentality. This goes through the entire construction industry. Something that I'm writing a lot about now is the supply-chain; which is the push and pull part of lean. I can never figure out how it applies to construction, but the concept is that every project is a prototype and so what we need to do is bring the team together, all the experts. How do we make it the most constructable? How do we get the best results? We need all that expertise. Most engineers do not know how to build things, they have an idea but they don't have the techniques. For example, when I got out of college, I am a civil engineer. I did surveying but when I showed up on the job I didn't know how to do it because I don't know the practical applications because I knew how to do it but not actually how to do it. In college they never teach you the practical part of it. You need the experts out there every day understanding the problems. I'm reading an article about steel fabrication, for example. When engineers do it they have all these crazy details. Whereas when the steel manufacturers do it they standardise every connection as much as possible, this reduces costs substantially because they know what to do and how to do it to make it

work. So the problem is we see, even in the professional part of the business, there is a lack of mutual respect back and forward. That's the key. We have to create mutual respect. We all have different skills. I'm always telling people I can write a book on what I know about construction, no problem; but I can write 10 books on what I don't know. We all just have a slither, a small slither on the industry. We have all these experts around us, but we have all kinds of inefficiency and problems. The problem is this lack of respect. This is why we have this resistance; until we resolve it we're not going to solve the problem. And this is what lean and some other approaches try to accentuate saying we have to collaborate. We need to respect one another.

Author: A quick question about the supply chain. When I say supply chain assistance is an important factor in lean construction, is it more about the main contractor assisting the downstream or the sub-contractors and the suppliers helping the main contractor to achieve sustainability?

Interviewee: I can break it into three pieces. The highest one starts with the design; this one you can't do without the owner's permission. Tiesto agreed that he's going to do a design build, an approach that will bring all the trade experts together. They can identify issues with materials, and deal with maintenance issues, not just constructability. If a guy is in the air-conditioning business, he knows what works and what doesn't. That's the first one, but that takes a mentality. We're going to get everyone participating in the design. The second step, all the contractors have it totally within their scope. Instead of me going out to 20 contractors for the lowest price I go out to the guy I think is the most qualified and I sit with him and try to work out how to lower his price. When we do this from project to project we'll simplify this process and learn from projects. So we build a relationship ongoing and it's a two-way street. He's helping the general contractor to be more efficient, the guys helping the sub-contractor to be more efficient and we're limiting the waste and the mistakes which will lower our costs and allows us to turn a lower bid. You have to know the qualifications; you need to go to someone with the expertise so it's a matter of matching up everybody. So you have that process but the general contractor doesn't have to go out and find 50 guys for the lowest price, he needs to find the lowest real price and he does that by working with him. The third one is really logistics; the logistics is managing the flow of the material. This gets back to lean, the whole process. According to statistics, on an average construction job the supplies of material that are going to be installed as part of the project are moved 4.5 times before

being installed. What's with that? Manufacturing has got to the point just in time for delivery so they don't have to store it and so they only handle it once.

Construction needs to do the same thing. Construction has never done that because it has always taken the attitude that it's not my responsibility. We tend to be very small companies; the average contractor only has 20 people. Then even when the companies get bigger they don't tend to do that. Project management teaches us to focus on our projects. One of my colleagues brought up a thing. He said if you're a major contractor in Sinsinaby, you may have 10 projects going on at a time and may be getting 10 deliveries from Chicago each week. If we worked as a company we could reduce it to five truck loads to save money. He says you're a small contractor so why not go to all the contractors in town and see what deliveries are coming from Chicago that week. Schedule them all to come at the same time and everyone will reduce their price. Statistics have found they can reduce the costs of a project by up to 4%. That is significant, when you think that a sub-contractor makes about 2.5%. Yet, by focusing on logistics we can reduce costs by 4%. So that's the three that I think you can do. But it is a collaboration thing and takes everyone to work together.

Author: Ok, I'll now ask two questions. First, in the UK we have qualifications called HNC and HND, which are slightly lower than degrees. I noticed that holders of these qualifications are more optimistic about lean compared to BSc and MSc students who are more pessimistic about lean. I feel that this may be down to work experience and because lean is more about processing. Maybe students leave universities substance thinking, focusing on final results rather than the process? Is this a correct observation in your opinion?

Interviewee: I think you have hit on something critical. I have never seen a study like that but I've had the experience without the study. The problem is that most of the kids that come out of college have no construction experience; they have never worked with the trades. They don't understand the problems. They have got all the theory from the professors and the big picture; you just do this. They often teach project management instead of lean in college so that's what they come out with and what they believe works. The other guys in the field, who have taken courses and who have practical experience, see that this isn't working and see the problems. So when a guy talks about lean they see that it can make a difference. They need that practical experience. They don't get it. I think you need that field experience as a balance. In the 70s, they took their engineers and put them in the field. The practical

applications that you learned were incredible. But too often now they make kids out of college project managers. They have no experience, they don't understand. So when kids graduate from college they have got a lot of gaps, just because they don't have any experience. So this is what I think part of the problem. Just do it mentality. They look down on the workers because they have a degree, and they're taught this. The officers help perpetuate that, telling them how smart they are. We see that in every industry.

Author: Ok. My next question is about the US Government; have they done anything to help implement lean? Maybe we can learn from the experiences.

Interviewee: They haven't done much. Too often, they are focused on this low-bid mentality. You still have a conventional wisdom that we need competition and the only way to get that is the low bid. And the low bid squelches a good part of that because it prevents the collaboration. Lean doesn't work. It works internally; you can improve your own efficiency. But the real problem is not internal to any one trade, it's between the trades. So I think no we have done a very poor job. That's why I keep writing and encouraging people to change. But it's a slow process as that's the way they have been doing business for hundreds of years.

Author: Regarding the strategies, what about a certification scheme to make it obligatory for all new workers/graduates to have a basic examination to demonstrate their awareness of lean, like with health and safety?

Interviewee: That's absolutely one of the things that should be done. That's the problem; what happens is people talk the buzz words but don't really do it. There has to be some sort of system. You need to make sure the person you're hiring has the credentials and if the credential's meaningful and you've made the person learn it then he can do the job. If they don't have it and they say they can it gives the impetus a bad need, for example design build. So you're absolutely right, they need a certification program. You could have different levels, because for example a foreman doesn't need to be at the same level as someone that's running a project.

Author: Yes. One other question please; it's about overcoming the lack of top management commitment. People here need to have certain experience and qualifications to achieve a chartered status; so why not include a condition concerning lean that he must have supervised

a certain amount of projects with lean, hold a specific certification or passed specific exams? Here, you will encourage managers to take training programs about lean and I consider it important to know about lean if you are a chartered engineer.

Interviewee: Yes, I agree with you. Part of the problem is that most people with degrees don't go back to school, that's the statistic. So they don't learn what lean is. I've read a dozen books on the subject, but I'm the exception. So I think we have to have a process to force people to do it and then they go I didn't understand this and finally a light bulb goes off. If everybody gets certified then that will become the norm, but it's going to take some effort because all the engineers are going to fight you but that's not to say we don't say it, try it and don't push it.

Author: How can I convince owners, especially those that don't know about lean? What will he gain if I tell him come have a lean certificate?

Interviewee: We have to show them. There is a concept called dominant proof; dominant proof is evidence that when anyone looks at it they can agree on the same answer. How you get dominant proof is by measuring. We need to measure performance, and when you start measuring lean projects versus non-lean projects you will start to see the performance difference. When you put that evidence in front of an owner he says I want to know more. So we have to measure, but there are enough lean projects out there to start gathering data and measuring. You need to have the data.

Author: Thank you for your time. Do you have any further comments before we end the interview?

Interviewee: Owners want lower costs. I think there's 30-40% waste in the system at least; this has been documented. But it's hard to get people to change; the only people we can change are those looking for a solution, those with an open-mind. As we see more success, more and more people will change. Then there are some that will never change. There are two key points, which are better pre-planning and management of the downstream supply; these are almost the same thing. It's bringing that effort together; in other words we need to put the time and effort in the front end to understand what we're trying to do and bring all the expertise. To expect the contractor to perform at high efficiency, we need to practice and

function as a team. That's exactly what's wrong with our industry; we have to change that concept that if we're going to compete at the highest level we need to practice and function as a team, and the only way we're going to achieve this is by applying these concepts. If you go to this downstream mentality then you have an opportunity to work lean together between the trades. If we do it over and over, it's the next project that is going to benefit from the ideas that you create on this project.

Author: That's great. It's been a very interesting interview. I have learned a lot, thank you very much.

Interviewee: My pleasure. If I can be of any further assistance, feel free to give me a call; I'm happy to work with you. I'd love to see you're report when you finally finish it.

Author: Yes of course. Thank you, bye.

A14.1.2 Interviewee number 2

This interview was also conducted through internet webcam on Skype program. The interviewee is a Productivity Manager/Lean facilitator in one of the leading contracting companies in the UK (AAT is almost equal to £1000 Millions); with (10-20) years of practical experience and holding a masters degree. The full transcript is provided below.

Author: The survey I conducted identified three major barriers: lack of adequate lean awareness and understanding, human and cultural issues and lack of top management commitment. I will ask you for your opinion on the nature of each of the barriers, starting with lack of adequate lean awareness and understanding.

Interviewee: Practitioners do not understand the basic concepts. The problem is that people see lean as tools rather than understanding its whole philosophy. Organisations which have taken up the complete philosophy are implementing lean more successfully than those who just focussed on the lean tools. Some companies say they are applying lean but they are not. This is because they do not have a lean culture/attitude within their organisation and it is not

applied on a broad system-wide focus Also, people think that lean will increase the amount of labour work which is not the case. By implementing lean they will improve the efficiency and effectiveness of the production.

Author: What about human attitudes and cultural issues?

Interviewee: culture implementation takes a lot of time because it is a change of mind-sets, behaviours and acts that you have adopted for a long time; and it gets resisted by humans by nature - reluctant to change. Within the UK construction industry or environment in general, there is an issue of human rights (e.g. you cannot discriminate, you do not need to restraint culture), and some people think to certain extent that lean may have a negative effect on their culture, which is not the case. Within an organisation, it will strengthen the relation between employees; and between organisations and their supply chain. However if your supply chain is not performing to your required standards you can change them. This is the message from the client now, if we as a contractor and our supply chain do not show to the clients that we are adopting a lean culture, we will not have work from them.

Author: That's brilliant, so how and why is there a lack of commitment from top managers?

Interviewee: top management wants to see the complete aspects of the cost benefit ratios. They want to see the benefits and the profits out of it, but they also have to understand that lean has to be implemented completely not by parts. If you implement lean by parts, you may gain benefits but you will never see the bigger picture. To understand the bigger picture, you have to take up the philosophy and establish a lean culture within the organisation. They have to focus on the philosophy and the culture rather than the tools. The problem is that the top management wants to see tangible benefits, big profits, time savings or anything which could enhance their relations with the clients, or an outstanding edge from the competitors. Another important issue is that top managers usually ask: how much money could I save? The people don't understand that lean is not for cost cutting. Lean will not cut your cost but yes it will save you money. There is two different ways of looking at things. If people say cost cuttings they will focus totally on cost cutting and ignore the main benefits. The benefits are that they will improve the flow of work, eliminate waste, improve productivity and improve the main productive hours

Author: One of the participants of my survey mentioned that in large organisations, there is a big gap between operational managements and top management. Do you agree?

Interviewee: I cannot generalise the case. However if there is a gap between operational managements and top management; to fill that gap we have to show the senior board the tangible benefits, in order to gain their interest.

Author: That is fine. Now, the second part of the interview will focus on the strategy to overcome these problems. Could you provide me with some recommendations or proposed ideas to overcome those three barriers we have just discussed?

Interviewee: There is a need to develop a training matrix in organisations for different levels of understanding. With that training the basic message will be seen, but for example if you give the training to the senior management, you will show them the cost benefits, middle management you can show them that out of the lean procedures they can reduce time, cost, and when you come to the bottom level (e.g. Juniors) you can show them that they could increase their productivity and finish their tasks in fewer hours. Each of these levels should understand and realise the benefits that they could gain from adopting lean. When you apply a training agreement you will try to understand the individual level and their perspectives.

I also believe that the government needs to create a state of emergency. One of the reasons health and safety is important is because it is law, so you have to do that. People are not very committed to lean or quality because it is not a law and they can get off with that!

Author: Do you think that lean principles need to be introduced to the curriculum at Universities and Colleagues to increase the awareness of Lean?

Interviewee: Absolutely, raising the awareness level right from academics at universities, colleagues and institutes is essential, so when graduates join companies they already have at least the basic levels of understanding and be more able to adopt with the procedures.

Author: Ok, I will tell you some comments I have received from other participants. I would like your opinion on them. One said that there is a lack of publicity, particularly of successful stories concerning lean. Do you agree?

Interviewee: Yes. A good solution is bringing the media and newspapers to highlight the success stories of companies that implement lean successfully, to increase the awareness of the public.

Author: Others highlighted the case of lack of incentives as a main barrier. Do you have any comments on that issue?

Interviewee: Benefits and profits that companies gain from applying lean should also be translated to the labour force or to anyone who contributed to achieving that profit. That will bring all the people together and each of them will get benefit out of it. Incentives are essential and don't have to be in the form of money only; incentives could be in the form of time-off, relaxation, working in a healthy environment, and even in the form of vouchers. Some companies just start doing lean and ask the labours to do more and they are not getting anything. That is a killer.

Author: Do you agree that benefits awarded should be based on the profitability of the production rather than productivity rates?

Interviewee: I strongly agree. That is because although the productivity rate may remain the same or even be slightly less (when applying lean), but as there is less waste it may be more profitable. On the other side may be before they had a higher productivity rate but they had to spend more time or waste more resources and thus reduce the profitability. 'They have to see the cost-benefit ratio'. To achieve this, companies need to establish cost and performance indicators.

Author: Would you recommend organisations to hire external consultants/lean facilitators?

Interviewee: Yes. When companies start to decide going on the lean journey, they need to have a steering group to take them to the right direction. They will need to hire an external consultant to make them understand the basic principles for a certain time, or allocate a lean facilitator/champion to educate the rest of the employees.

Author: Do you agree that procurement should be based on organisations' lean initiatives rather than the traditional approach of just selecting the lowest price?

Interviewee: If the Government pushes the agenda, clients will be encouraged to base the selection of their supply chain on those who can demonstrate their lean attitude and lean maturity. An example of this is the BAA, and the HALMAT produced by the HA. Similarly, Network rail as a client and Cross rail as a client, should both follow the same approach. That could be the best direction or route. However, even if the government does not push the agenda, it could still be done still if the major clients in the UK such as the HA, BAA, Cross Rail, Network Rail, etc. make a block and make it very clear to their supply chain that they must demonstrate their Lean initiatives along with their career profile in order to win any bids.

Author: As you mentioned earlier, health and safety was previously ignored, but since the government made it a law it has become a priority. Now everyone who works on a site must take a construction health and safety test. I proposed that in order to increase lean awareness, a lean construction certification scheme should be implemented. This could cover the basics and as with the health and safety test different levels of workers could take different levels of exams. Do you agree with that?

Interviewee: The government is strongly recommended to establish a Lean Construction Certification Scheme (LCCS), with the same idea of the CSCS, to provide practitioners with required knowledge at different levels. This will help to break down the cultural issues, and provide at least a basic level of awareness and understanding to Lean principles. It has been noticed that Governmental reports such as (Latham's and Egan's report increased the industries' awareness to the importance of quality and productivity. A certification scheme established by the government will definitely lead to a positive take up and a positive culture change.

Another good idea is that professional institutions need to add LC to their objectives; which means that every engineer needs to demonstrate a specific level of Awareness and understating to lean principles as a condition for obtaining a chartered or incorporated status. This will encourage practitioners to go for lean training programmes.

Author: Last question please. Do you agree that organisations need to device their own metrics for evaluating performance, so that the lean could be successfully implemented? Perhaps, creating something similar to the HALMAT, which suits their business needs?

Interviewee: Yes. Organisations need to Establish a lean measurement assessment tool to evaluate the lean maturity levels of their supply chain such as that produced by the HA. However, one concern about the HALMAT is that it is mainly based on a qualitative analysis rather than a quantitative one. When it comes to measuring a culture, it is difficult to bring it into numbers (quantify it). Thus, this issue needs to be carefully addressed. One proposed solution is that companies may have to show from their previous projects what sort of cost benefits have they saved and how they achieved that.

Author: OK, so finally I would like to ask if you are happy with the way the interview has been conducted. Do you have any other comments?

Interviewee: Thank you, it was fine. You have already taken up a very brave step by taking up a project at this level for an MSc study; and I wish you all the best.

A14.1.3 Interviewee number 3

This interview was conducted by telephone. The interviewee is a Quality/Business Improvements Manager in a medium construction organisation (£100-1000 Millions); has 5-10 years of experience and holding an NVQ degree. The full transcript is given below.

Author: One question from the questionnaire asked participants to arrange barriers in order of their influence. The top three barriers identified were lack of adequate lean awareness and understanding, cultural barriers and lack of top management commitment. So for the first question, I want to your opinion about the nature of these barriers.

Interviewee: Cannot hear what is being said ...If they don't explain what's happening and why it's happening then generally that lack of knowledge turns off, if you know what I mean?

Author: Yes, so is it more about using unsuitable methodologies or that they are not aware of the basic principles, or is it both?

Interviewee: It can be both of them. In the construction industry now people have started to acknowledge that lean is a good way to go but there are instances where they say that sounds good, go and do it.

Author: Yes, go on and do it without adequate planning.

Interviewee: Exactly.

Author: So what kinds of cultural issues/barriers hinder the implementation of lean construction?

Interviewee: The usual excuse is that this is the way we have always done it. Culturally, people get settled in what they're doing, no matter where they're from. Change is seen as adding more work.

Author: Someone told me that because of human rights laws in the UK that state that you cannot restrain culture so some people due to lack of understanding feel that lean is an approach that goes against their human rights. For example, if they don't do well they may get fired. Do you understand?

Interviewee: Yes, I understand what they're saying. But it's not that easy as that now. I mean, firing is always the last resort. You deal with the process, make sure that the process is correct for business, monitor and tweak it; if someone is then still not performing you then follow the correct procedures and you can get rid of them.

Author: But you are allowed to do that with your supply chain if they're not meeting your standards? That's nothing to do with human rights, it's just business right?

Interviewee: Yes, with your supply chain it's completely different. You sign a contract, if it's a good contract it will outline expectations, targets and objectives that will get monitored.

If they're really under-performing then you can terminate the contract and pass it to someone else.

Author: Last question about lack of top management commitment, how does that happen? Do they agree with the idea but not follow it, or do they not agree with it from the beginning?

Interviewee: It depends where your top management starts.

Author: Sorry, does it always mean the senior board or just the managers above you?

Interviewee: It's an interesting one. It depends on the set-up of the company. I would say the managers above me. If my company was a big company, with lots of smaller companies running within it and someone at the top decides that that's what you're going to do but the smaller companies don't then that's where that can happen.

Author: Fine, ok. So now the second question concerns a strategy for overcoming these barriers. So firstly, how can we overcome the lack of adequate lean understanding and awareness?

Interviewee: Well, it's about information isn't it and seeing is believing. You have to talk to your people and make sure that they're involved. I'm very much a fan of 5S/SMED.

Author: Can we talk about 5S quickly please as all I know from literature is that it can be used for organising a warehouse but elsewhere I have read that it is not only limited to that, that's just how you start organising your company or organisation. So what is meant by 5S?

Interviewee: 5S is derived from the production manufacturing. So the first S is system sort, where you sieve through your stuff and see what you want to keep. The second one is straightening so you put it in, in an organised manner. The third S is sweep and shine, so you clean it up and make it presentable. The fourth one is standardise so what you do should be the same everywhere. The last one is sustain, so you keep it going and improve it. A lot of examples are around warehouses and depots but you can apply those five principles to anything you do.

Author: Ok. So what do you think about training, whether formal training or having a training matrix for different levels? Do you think a formal training agreement is necessary for lean?

Interviewee: Absolutely. If you look at the top-performing companies, they have it built in. So if someone joins they will be trained in the basic lean principles. On the other hand, I would say that it could be part of the induction.

Author: Yes, but does that mean that lean has to already be part of the strategy used by the company?

Interviewee: It depends what level you want to go in at. If I employed someone to work for me I would spend a week giving them an induction and include my lean stuff in with it. If it was offsite then it's slightly different; here we go back to the 5S stuff, where you can practically do it. So ideally you would have a week for your employees to learn the principles and then onsite they should be doing it.

Author: Ok. Also, can the government help to disseminate lean principles amongst the construction industry?

Interviewee: It comes down to money. If they threw a bit more money and regulations on it maybe yes. In a business you want to make profit.

Author: Yes. One individual told me that because lean isn't a law people think that they can get out of it. Because health and safety became a law, it is a priority for designers for example. Here I thought as the government made a health and safety certification scheme, maybe they could do a lean construction certification scheme?

Interviewee: In the last company I worked for we actually rolled out a Level 2 NVQ in Lean Business Improvement. It went through the basics of ... and we had to find something that needed to be improved and that's what we got marked on. It was a massive success. It was spread across 60 people, including people from our business and from the client we worked for. It made us work together, and it was really good. The only issue was the amount of time it consumed, but the benefit we got was massive.

Author: Ok, so yes. I'll now move on to the second barrier. I think we can overcome cultural issues by education and training, for example rolling out NVQs like you just mentioned.

Interviewee: Yes.

Author: Lack of top managing commitment. I was talking to a manager from another company recently; he told me that the middle management has to show their managers the cost benefit ratio from applying lean. But how can middle management do that if they don't have the resources and tools to help them do that?

Interviewee: They can't effectively. It all depends on the manager. It's generally those who are organised and methodical who meet their targets and budgets. Then you get the other guys who just go out and do what they need to do to get by but can hit their targets. It can be manipulated as well. But you're quite right, how do they do that if they don't know how to apply it. The answer is they can't. It needs to be directed from the top down and filter down to the bottom. Once it hits the bottom it then needs to rebound back up.

Author: Yes. I'll now give you some statements and I want your comments on them. What about the highway agency, they now encourage their supply chains to go on the lean journey and have created their own assessment tool to ensure all their suppliers have lean maturity. Do you think all major clients in the UK can follow the same approach and encourage all companies to go lean in order to win bids? This may also push the agenda of the government.

Interviewee: Absolutely. I mean the highway agency works for the government. We work for the highways agency. So it's that filtering down. The HA supply chain is massive.

Author: What made the HA take such a big step?

Interviewee: Basically it's because they realised they were getting ripped off. They were overpaying for lots of stuff. The other key driver was because there isn't much money around anymore and the government is tightening their purse.

Author: So what has lean got to do with this?

Interviewee: Lean will make their review how they operate. It comes down to processes, making sure that they work for them and the people that are feeding into them. It will also look into how you get paid and the way it's being carried out. So it's a just tool to do that in a methodical and effective way.

Author: Ok. About the HALMAT, the highway lean maturity assessment tool. I have been told that it is based on more qualitative analysis, not numbers. So it may not be completely fair. For example, someone may visit your organisation and score your staff following an interview. The score he gives will be more based on his own judgement.

Interviewee: I think qualitative has kicked in now because the highway agency is interested in how much it's going to cost and how long can you guarantee it's going to last. So the reason they're doing that is because they're focusing on the long-term rather than short-term.

Author: Ok, if a company wants to start on the lean journey do they need to employ an external consultant?

Interviewee: I believe they do. I learned what I know from an external consultant agency. If you don't it's down to interpretation.

Author: Is it for a certain amount of time, until one of the team leaders picks up the ideas and take over as team facilitator?

Interviewee: Yes, absolutely. We had a consultant company in for six months; it cost a lot of money, but the benefits were great. We did nine weeks of rolling out across the whole workforce, about 150 people, and from that about six people were identified to be lean champions. So we had extended training; we shadowed the consultant agency through another business. It was all based around practical training. One week in a classroom and five weeks practical training.

Author: Are they that expensive? How can small companies afford them?

Interviewee: It's about how long you have them. They are expensive but if you embrace it you'll get your return on it in the next six months. Small organisations should not worry so much about financial problems as they will need an external consultant for less time than large organisations because they have fewer employees

Author: What about showing lean awareness in order to gain chartered or incorporated status in order. This may encourage managers to attend lean training seminars and programmes.

Interviewee: I personally agree with that. But you'll be hard pushed to find a majority who agree with that. One of the comments I always get is we are doing it in the first place, but obviously people aren't because if they were we wouldn't be embarking on a lean journey. But I think that idea is good but you'd have to be quite specific as to who would do it.

Author: Ok. One of the participants gave me a good example. Health and safety was previously ignored, but since the government made it a law it has become a priority. Now everyone who works on a site must take a construction health and safety test. I proposed that in order to increase lean awareness, a lean construction certification scheme should be implemented. This could cover the basics and as with the health and safety test different levels of workers could take different levels of exams. Do you agree with that?
Interviewee: Yes, a certification scheme would help to increase the level of awareness. I also do recommend NVQ lean courses.

Author: Thank you very much, that was great.

Interviewee: No worries, thanks very much. If you need anything else give me a shout.

Author: Thank you, bye.

A14.1.4 Interviewee number 4

This was a face to face interview. The interviewee is an Architectural Designer (recent junior) in a small organisation (£1-10 Millions); holding a masters degree and starting recently a doctorate study. The full transcript is provided below.

Author: The survey I conducted identified three major barriers: lack of adequate lean awareness and understanding, human and cultural issues and lack of top management commitment. I will ask you for your opinion on the nature of each of the barriers, starting with lack of adequate lean awareness and understanding.

Interviewee: I have done a similar previous research on the application of lean philosophy to Architectural firms and the aim was to find out the understanding of lean and if people are aware of it. I broke down the lean tools and techniques using simple words, for example I asked companies if they used 3D AutoCAD. Many companies did. What they didn't realise was that that is a lean tool. That is just an example. My questionnaire actually asked them if they knew about lean construction institute and the term lean, and many of them didn't. But the next question broke down lean, putting it in simple terms and many of them answered yes. So I think people are using lean, but without realising. So the awareness isn't there, and therefore there is a need for them to have that appreciation of lean. Even when I started my research, my main aim was to improve the process efficiency and at that point I didn't know anything about lean. I went and did some research and was not able to link lean with what I wanted to achieve, which was lean efficiency in the office. So I think it is just a term that's out there that not many people know.

Author: Ok. So what about human and cultural issues? How does that act as a barrier?

Interviewee: Yes, ok. I did my MSc thesis and came back to the office very keen to implement lean tools and techniques, but the office was very resistant to change. People get very used to the way they do things and have been very reluctant to accept change. For example, I have proposed that they use Revit instead of 2D AutoCAD but they are not ready to change.

Author: Ok, what about lack of top management commitment?

Interviewee: Yes, I think that is also very important because in the present climate with the recession top management is not interested in investing. But what they don't realise is that it is a long-term investment but they think for right now it is a waste of time. Obviously, if the management is not involved it's going to be hard to get the people underneath involved. So

management need to take the initiative and get involved, and then filter it down to the staff to let them know yes this needs to be done and then probably that could help to remove the barrier.

Author: Ok, so is lack of top management commitment related to understanding? Perhaps they are not committed due to lack of understanding? Or are there other reasons, for example cultural issues? What do you think is the main reason?

Interviewee: In my personal opinion, I don't think they're ready to invest their money at this moment in time.

Author: So now, the interview focuses on proposing a strategy for overcoming these barriers.

Interviewee: Ok. I have been doing a bit of research and I think, rather than picking up lean tools and techniques and saying let's apply them, what needs to be done is to have group meetings. Management should be involved as well, so the team can understand the process and work out how to improve it. It will allow the team to come up with a combined strategy to overcome the issues and will allow everyone to get involved.

Author: Ok, I will tell you some comments I have received from other participants. I would like your opinion on them. One said that there is a lack of publicity, particularly of successful stories concerning lean. Do you agree?

Interviewee: Yes, I don't think that it is well published because I have only come across it because I'm interested in the topic. If I hadn't been I don't think I would have even known what lean was.

Author: Ok. Another participant suggested that clients should be encouraged to select contractors and designers who engage in lean practices, using a set of criteria to help them. The Highway Agency has done this. Their supply chain has to be involved in lean and they do a survey on the companies that work with them based on their application of lean. Some people think this a good idea and with the Highway Agency being a governmental organisation this may influence companies to go lean. Do you agree or are you against forcing companies?

Interviewee: Even the government is saying that by 2016 all design companies should be using BIM, which will force them to use lean. I think that this is good, because left to them they wouldn't do it.

Author: Ok. Do you think the government can make the real difference to help implement lean?

Interviewee: Yes, they are trying to achieve this zero waste target which has a deadline. The only way to achieve this is by implementing lean tools and techniques because lean is all about minimising waste.

Author: Ok. One of the participants gave me a good example. Health and safety was previously ignored, but since the government made it a law it has become a priority. Now everyone who works on a site must take a construction health and safety test. I proposed that in order to increase lean awareness, a lean construction certification scheme should be implemented. This could cover the basics and as with the health and safety test different levels of workers could take different levels of exams. Do you agree with that?

Interviewee: There are already some certifications for lean, for example with the black belts.

Author: But I think that that type of certification you just mentioned focuses more on methodologies, rather than basic awareness. So what would your opinion be of my suggestion?

Interviewee: I'm not sure. I wouldn't say no though, so I'd say I'm neutral.

Author: Ok. Do you have anything else to add to the interview?

Interviewee: Ok, from my own understanding of lean, small companies aren't really interested. But I did a bit of research, and noticed that big companies and contractors are investing into lean. There is in fact a PhD proposal going on about optimising process energy and carbon efficiency which is being sponsored by a construction company. So they are interested in finding out what tools and techniques can be used, but at this point they

probably don't have lean in mind. But this can be achieved using lean, which they may not be aware of.

Author: Ok, so last question. How to diffuse lean and increase awareness across the construction industry?

Interviewee: I am a member of CIOB and when I go for their meetings they always talk about Constructing Excellence; which does a lot with lean. Apart from that I don't hear much about them. So I think there is a need to increase awareness.

Author: So you think professional institutions should organise occasional seminars on lean for their members to increase their awareness?

Interviewee: Yes.

Author: Ok, great. Thank you.

Interviewee: You're welcome